# Self-adaptive Search Equation-Based Artificial Bee Colony Algorithm with CMA-ES on the Noiseless BBOB Testbed\*

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## ABSTRACT

Self-Adaptive Search Equation based Artificial Bee Colony (SSEABC) is a recent variant of Artificial Bee Colony (ABC) algorithm. SSEABC proposed three enhancements on the canonical ABC algorithm. These are the self-adaptive search equation selection strategy, hybridization with a local search procedure and incremental population size strategy. The performance of SSEABC is tested on CEC 2015 benchmark suite and ranked third within all participants of competition. In this paper, we benchmark SSEABC using the noise-free BBOB function testbed. We also compare SSEABC performance to PSO, ABC and GA algorithms.

## **CCS CONCEPTS**

•Mathematics of computing → Probabilistic algorithms; •Theory of computation → Mathematical optimization; Random search heuristics; Theory of randomized search heuristics; •Computing methodologies → Search methodologies;

## **KEYWORDS**

Artificial Bee Colony, Continuous Domains, Self-Adaptation, Benchmarking

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# **1** INTRODUCTION

Ever since the Artificial Bee Colony (ABC) algorithm came into existence [11], it has been used in solving continuous optimization problems. However, failure to produce successful results in some types of problems has led to the emergence of many improved ABC variants in recent years. Many of these algorithms have suggested enhancements over one or more of the steps of the ABC algorithm

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[1, 3]. A recent research [1] has shown that the best improvements can be made with changes to the employed bees and onlooker bees steps or with new extensions to the canonical ABC algorithm.

A recent ABC variant, Self-adaptive Search Equation based Artificial Bee Colony (SSEABC) [14], is focused on these remediation methods. The SSEABC algorithm solves the problem of finding the appropriate search equation in the employed bees and onlooker bees steps in a self-adaptive way. On the other hand, the algorithm has been improved with iteratively increasing the number of populations and using local search procedures.

SSEABC algorithm performance has been compared with ABC and many contemporary algorithms on CEC 2016 benchmark functions suite and it has been observed that we have obtained successful results [14]. In this paper, the performance of SSEABC algorithm on the BBOB functions testbed has been tested.

## 2 ALGORITHM PRESENTATION

SSEABC proposes three modifications on the original ABC algorithm to improve performance. These strategies are based on the self-adaptive search equation selection, hybridization with a local search procedure and increasing population size during execution. The pseudo-code of SSEABC is presented in Algorithm 1.

Self-adaptive search equation selection: In solving numerical optimization problems, the most important factor affecting the performance of ABC algorithm is the search equations that take place in the steps of employed bees and onlooker bees. In addition to the search equation, the number of dimensions considered to be changed is another important factor affecting the performance of the algorithm. When considering the structure of the problem and that is supposed to be solved; determining the appropriate search equation becomes a difficult task. Thus, in this study, a mechanism has been developed that determines the appropriate search equation among the various candidates. To do this, SSEABC has proposed a search equation pool which is filled with randomly generated search equations. The general template of candidate search equation is as seen in Algorithm 2.

The candidate search equations take the form of four terms with alternatives in Table 1 with M values. At initialization step of the algorithm, the pool, S, is filled by randomly generated search equation using Algorithm 2 and Table 1.Then, at each iteration a candidate search equation from the pool is used in the employed bees and onlooker bees steps. This process repeats until all candidates used in the pool. Throughout these steps, the number of success rates of the search equations that provide the update of the solution is increased. After all the candidate search equations in the pool are

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Algorithm 1 The Pseudo-code for the SSEABC algorithm

•		
f	unction SSEABCMAIN	
2:	Initialization	
	fill search equations pool, S, with randomly generated	search equations
4:	itr = 0	
	isCompetitionNeeded = TRUE	
6:	while termination condition is not met do	
	<pre>EmployedBeesStep(S[itr (mod ps)])</pre>	$\triangleright$ it also counts number of successful updates with <i>S</i> [ <i>itr</i> (mod <i>ps</i> )]
8:	OnlookerBeesStep(S[itr (mod ps)])	$\triangleright$ it also counts number of successful updates with $S[itr \pmod{ps}]$
	ScoutBeesStep()	
10:	X <sub>gbest</sub> = getBestFoodSource()	
	<b>if</b> currentFES ≥ tr * MAXFES & isLocalSearchCal	lNeeded == TRUE <b>then</b>
12:	$applyLocalSearch(X_{gbest})$	
	<b>if</b> $SN < SN_{max}$ and <i>itr</i> (mod $q$ ) == 0 <b>then</b>	$\triangleright$ Incemental population size strategy
14:	add new solution to the current population by	using Equation 2
	if all search equations are used then	$\triangleright$ A part of the self-adaptive search equation determination strategy
16:	shrink the search equations pool size .ps. with 1	Equation 1
	itr - itr + 1	1
18.	<b>return</b> $X$ , as the best solution	
10.	gbest as the best solution	

Algorithm 2 The general form of the search equ	ation	
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1: **for** m = 1 to M **do** 2: select random dimension j  $(1 \le j \le D)$ 

3:  $x_{i,j} = term_1 + term_2 + term_3 + term_4$ 

used in the employed bees and onlooker steps, *ps*, which is the size of the pool, is scaled down by the equation 1:

$$ps = \frac{ps^2}{itr_{MAX}} \tag{1}$$

where *MAXFES* is the maximum number of function evaluations for one execution and  $2 \times SN$  is the number of function evaluations at each iteration and where  $itr_{MAX}$  is the approximated value of the maximum number of iterations.  $itr_{MAX}$  is the approximated value because the incremental population size strategy in which *SN* is changing over time. Finally, when the algorithm finishes its execution, very few search equations, which are the appropriate ones, remain in the pool only.

*hybridization with a local search procedure.* : In SSEABC algorithm, bees move using the SSEABC rules and by the invocation of a local search procedure. Specifically, best-so-far solution is used as the initial solution a local search procedure is called from. The final solution found through local search becomes the new best-so-far solution if it is better than the initial solution. In SSEABC, the local search procedure is called only when it is expected that its invocation will result in an improvement of the-best-so-far solution. In previous implementation of SSEABC [14], competitive local search selection procedure was used. However, for the BBOB testbed, we used CMA-ES algorithm [12] as the local search procedure because competitive local search selection provides a wasteful use of function evaluations.

Table 1: Alternative options for each component in the generalized search equation.  $x_{G,j}$ ,  $x_{GD,j}$ ,  $x_{SC,j}$ ,  $x_{MD,j}$ ,  $x_{WO,j}$ and  $x_{AVE,j}$  are best-so-far, best-distance, second best, median, worst foods sources at dimension *j*, respectively. On the other hand,  $X_{r1}$  and  $X_{r2}$  are two randomly selected food source and  $x_{AVE,j}$  refers to average positions of the food source at dimension *j*.  $\phi_N$  can take two possible ranges: [-1, -1] and [-SF, SF] where SF is randomly selected positive real value. These ranges are decided randomly while creating each component of randomly generated search equation.

М	term1	term2    terms3    terms4
1	$x_{i,j}$	$\phi N(x_{i,j} - x_{G,j})$
$k \ (1 \le k \le D)$	$x_{G,j}$	$\phi N(x_{i,j} - x_{r1,j})$
$[t,k] (1 \le t < k \le D)$	$x_{r1,j}$	$\phi N(x_{G,j} - x_{r1,j})$
		$\phi N(x_{r1,j} - x_{r2,j})$
		$\phi N(x_{i,j} - x_{GD,j})$
		$\phi N(x_{i,j} - x_{SC,j})$
		$\phi N(x_{i,j} - x_{MD,j})$
		$\phi N(x_{i,j} - x_{WO,j})$
		$\phi N(x_{SC,j} - x_{MD,j})$
		$\phi N(x_{MD,j} - x_{WO,j})$
		$\phi N(x_{G,j} - x_{WO,j})$
		$\phi N(x_{r1,j} - x_{MD,j})$
		$\phi N(x_{G,j} - x_{MD,j})$
		$\phi N(x_{r1,j} - x_{WO,j})$
		$\phi N(x_{SC,j} - x_{r1,j})$
		$\phi N(x_{i,j} - x_{AVE,j})$
		$\phi N(x_{r1,j} - x_{AVE,j})$
		$\phi N(x_{G,j} - x_{AVE,j})$
		DoNotUse

Incremental population size strategy: This strategy is very similar to the incremental social learning (ISL) framework [2, 4]. According to this strategy, SSEABC starts to work with a small population. During the algorithm execution, a new solution influenced by the best-so-far solution is added to the population after a certain number of iterations called growth period, *g*. This addition process continues until the maximum population value is reached. The solution to be newly added to the population is created using the equation 2:

$$\dot{x}_{new,j} = x_{new,j} + \varphi_{i,j} (x_{G,j} - x_{new,j})$$
<sup>(2)</sup>

where  $\dot{x}_{new,j}$  is the new solution to be added.

## **3 EXPERIMENTAL PROCEDURE**

We have used the default parameter values for SSEABC and CMAES algorithms which were given in [14] and [12] respectively. A maximum of  $10^4D$  function evaluations was used. Every periodic 2500*D* function evaluations SSEABC restarts without forgetting the best-so-far solution.

### 4 CPU TIMING

In order to evaluate the CPU timing of the algorithm, we have run the SSEABC on the f8 without restarts 30 seconds and until a maximum budget equal to 1000*D* is reached. The C++ code was run on a Intel Xeon E5410 quadcore CPUs running at 2.33 GHz with 2 x 6 MB L2 cache and 8 GB RAM. The time per function evaluation for dimensions 2, 3, 5, 10, 20, 40 equals 0.0041, 0.0082, 0.0146, 0.627, 1.421, and 2, 751 seconds respectively.

## **5 RESULTS**

Results from experiments according to [10] and [6] on the benchmark functions given in [5, 9] are presented in Figures 1, 2 and 3 and in Tables 2 and 3. The experiments were performed with COCO [8], version 2.0, the plots were produced with version 2.0.

The **average runtime (aRT)**, used in the figures and tables, depends on a given target function value,  $f_t = f_{opt} + \Delta f$ , and is computed over all relevant trials as the number of function evaluations executed during each trial while the best function value did not reach  $f_t$ , summed over all trials and divided by the number of trials that actually reached  $f_t$  [7, 13]. **Statistical significance** is tested with the rank-sum test for a given target  $\Delta f_t$  using, for each trial, either the number of needed function evaluations to reach  $\Delta f_t$ (inverted and multiplied by -1), or, if the target was not reached, the best  $\Delta f$ -value achieved, measured only up to the smallest number of overall function evaluations for any unsuccessful trial under consideration.

From the experiments, we observed that SSEABC solved 11 functions in dimension 5 and 5 functions in dimension 20 with 100% success rate. Over from dimension from 2 to 20, SSEABC solved  $f_1$ ,  $f_5$ ,  $f_6$ ,  $f_7$ ,  $f_8$ ,  $f_9$ ,  $f_{11}$ ,  $f_{12}$  and  $f_{21}$ . It is also seen that  $f_4$ ,  $f_{19}$ and  $f_{24}$  are the most difficult problems for SSEABC. For both 5 and 20 dimensional problems, SSEABC can not reach the optimum result in any instance. On the other hand, when the problem size increases, the performance of the SSEABC algorithm decreases. As seen in 20-D results, 13 out of the 24 functions have not been solved to the hardest target  $10^{-8}$ . Comparison of SSEABC algorithm to PSO, ABC and GA in previous BBOB workshops are presented in Figure 2. We have seen that SSEABC outperforms PSO, ABC and GA for almost all functions. Moreover, SSEABC obtains better run-time performance than reference algorithms on the moderate, ill-conditioned and multi-modal functions. When the comparison results are examined, SSEABC for f4 and f20 seems to give bad results from ABC. Although SSEABC is an improved variant of the ABC algorithm, it is surprising at first glance that this situation has emerged. However, this is related to the fact that the entirely selected local search algorithm does not work well on these problems. The use of a certain amount of the function evaluations budget by CMA-ES yields this result.

## 6 CONCLUSION

In this paper, we present the benchmark results of SSEABC algorithm on BBOB functions testbed. We have also compared the performance of SSEABC to the data obtained by PSO, ABC and GA algorithms. The comparison results showed that SSEABC algorithm can outperforms the compared algorithms and it is very competitive to (1+1)-CMA-ES and BIPOP-CMA-ES in moderate and ill-conditioned functions.

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Figure 1: Average running time (aRT in number of f-evaluations as  $\log_{10}$  value), divided by dimension for target function value  $10^{-8}$  versus dimension. Slanted grid lines indicate quadratic scaling with the dimension. Different symbols correspond to different algorithms given in the legend of  $f_1$  and  $f_{24}$ . Light symbols give the maximum number of function evaluations from the longest trial divided by dimension. Black stars indicate a statistically better result compared to all other algorithms with p < 0.01 and Bonferroni correction number of dimensions (six). Legend:  $\circ$ : PSO,  $\diamond$ : GA, \*: ABC,  $\bigtriangledown$ : SSEABC



Figure 2: Bootstrapped empirical cumulative distribution of the number of objective function evaluations divided by dimension (FEvals/DIM) for 51 targets with target precision in  $10^{[-8..2]}$  for all functions and subgroups in 5-D. The "best 2009" line corresponds to the best aRT observed during BBOB 2009 for each selected target.



Figure 3: Bootstrapped empirical cumulative distribution of the number of objective function evaluations divided by dimension (FEvals/DIM) for 51 targets with target precision in  $10^{[-8..2]}$  for all functions and subgroups in 20-D. The "best 2009" line corresponds to the best aRT observed during BBOB 2009 for each selected target.

#### SSEABC with CMA-ES on the Noiseless BBOB Testbed

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$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f1	11	12	12	12	12	12	12	15/15	f13	132	195	250	) 319	1310	1752	2255	15/15
PSO GA	3.7(2) 8.7(16)	22(9) 369(261)	56(18) 1202(122)	117(24) 2130(335)	185(15) 2989(447)	322(40) 5474(410)	458(67) 8468(495)	15/15	PSO GA	1582(4308) 243(34)	1.0e4(1e4) 726(57)	2.8e4(2e4) 4390(4528	) ∞ ) 2.3e4(2e	4) 00	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	∞ 5e5 ∞ 5e5	0/15
ABC	12(14)	32(20)	63(22)	90(42)	124(24)	194(18)	259(14)	15/15	ABC	18(15)	187(310)	6613(8618	) ∞	+) ∞ ∞	~	∞ 5e5	0/15
SSEABC	5.9(3)	12(2)*2	18(0.9) <sup>*3</sup>	26(3) <sup>*4</sup>	32(3) <sup>*4</sup>	45(2) <sup>*4</sup>	56(4) <sup>*4</sup>	15/15	SSEABO	3.8(1)*2	5.9(2) <sup>*4</sup>	6.5(4)	<sup>*4</sup> 6.7(1) <sup>*4</sup>	1.9(0.4)*	4 <b>1.8</b> (0.2)*4	1.8(0.2) <sup>*4</sup>	15/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f2	83	87	88	89	90	92	94	15/15	f14	10	41	58	90	139	251	476	15/15
PSO	32(8)	41(7)	49(6)	60(6)	68(11)	89(16)	106(13)	15/15	PSO	1.8(2)	5.6(2)	15(2)	21(5)	29(8)	219(291)	∞ 5e5	0/15
ABC	11(3)	459(54) 18(9)	26(8)	30(17)	38(10)	2150(4125) 50(8)	2555(117) 62(7)	15/15	ABC	3.4(2)	90(44) 11(10)	267(55) 19(6)	29(11)	549(66) 677(1236)	~	∞ 5e5	0/15
SSEABC	15(4)	18(4)	19(2)	20(2)	21(2)*3	22(2)*4	23(1)*4	15/15	SSEABO	3.0(4)	3.7(0.7)	4.4(1)*4	4.4(0.9)*4	4.8(0.6)*4	5.7(0.6)*4	4.6(0.3)*4	15/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
f3	716	1622	1637	1642	1646	1650	1654	15/15	f15	511	9310	19369	19743	20073	20769	21359	14/15
PSO	52(1)	55(3)	275(306)	275(305)	275(685)	276(304)	276(229)	8/15	PSO	16(72)	221(253)	366(910)	359(437)	353(467)	342(590)	333(275)	1/15
GA	19(2)	18(1)	25(2)	34(3)	43(5)	112(80)	200(156)	11/15	GA	35(6) 15(6)	91(175) 243(161)	367(538)	361(242)	355(331)	345(429)	∞ 5e5 ∞ 5e5	0/15
SSEABC	1.0(0.5)	9.2(7)	49(70)	2.4(0.4) 74(122)	2.7(0.5) 132(122)	3.6(0.4) 132(83)	4.4(0.7) 210(165)	2/15	SSEABO	1.2(0.3)*3	0.93(0.3)*3	1.0(0.9)*4	1.1(0.6)*4	1.7(1.0)*4	7.9(8)*4	10(15)*4	1/15
Afant	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	Afant	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
	809	1633	1688	1758	1817	1886	1903	15/15	-50pt	120	612	2662	10163	10449	11644	12095	15/15
PSO	3.0(0.9)	141(232)	4152(2296)	3988(4764)	3859(4403)	3719(5435)	3687(2562)	1/15	PSO	2.4(3)	6.2(7)	59(59)	55(28)	89(96)	300(333)	580(486)	0/15
GA	18(3)	20(2)	26(1)	33(4)	41(6)	58(4)	185(70)	9/15	GA	2.1(2)	84(65)	93(95)	71(114)	148(111)	621(345)	605(706)	0/15
ABC	1.1(0.5)	2.4(0.5)	2.9(2)	3.4(1)	4.3(2)	4.9(0.9) · · ·	6.0(1) ~ ·	15/15	SSEARC	2.3(2)	20(3)*	4 1(6)	14(1)*	19(2)*2	3 8(7) *2	18(35)*2	3/15
AF .	1 2.7(3)	1:0	10.1	10.2	10.2	10.5	10.7	#	AF .	1.0(2)	1:0	10.1	10.2	1.5(2)	10.5	10(55)	5/15
f5	10	10	10	10-2	10-5	10	10	15/15	f17	5.0	215	899	2861	3669	6351	7934	15/15
PSO	10(1)	14(2)	<b>16</b> (4)	16(7)	16(7)	<b>16</b> (7)	16(6)	15/15	PSO	3.4(2)	169(583)	142(0.8)	156(350)	548(239)	514(433)	420(438)	1/15
GA	481(227)	2072(340)	3983(177)	6349(609)	9220(737)	1.7e4(1635)	3.4e4(2591)	0/15	GA	5.6(2)	46(13)	36(1)	52(4)	189(190)	550(1166)	∞ 5e5	0/15
ABC	32(34)	49(20)	58(30)	59(29)	59(32)	59(34)	59(29)	15/15	ABC	6.8(7)	15(7)	64(46) 1 4(2) *2	1259(798)	∞ 1 a(0 0) *3	∞ 20(18)*	∞ 5e5	0/15
SSEABC	0.0(3)	22(26)	34(32)	41(43)	46(29)	51(32)	51(68)	15/15 I#	SSEABC	4.4(5)	1.1(0.3)	1.4(3)	1.2(1)	1.2(0.9)	20(18)	<b>90</b> (109)	1/15
<sup>Δ</sup> Jopt f6	111	214	281	10-2	580	1038	1332	#succ 15/15	Jopt	103	378	3968	8451	0280	10905	12460	#succ
PSO	4.7(5)	9.0(3)	11(3)	12(3)	11(3)	10(2)	11(1)	15/15	PSO	2.3(2)	6.6(5)	113(95)	253(414)	∞	∞	∞ 5e5	0/15
GA	66(34)	148(61)	382(73)	3680(4345)	1.2e4(2e4)	~	∞ 5e5	0/15	GA	22(18)	59(15)	34(3)	134(154)	$\infty$	$\infty$	∞ 5e5	0/15
ABC	4.9(3)	15(9)	365(36)	408(51)	619(665)	498(362)	507(705)	6/15	ABC	5.1(4)	27(27)	300(368)	∞ 	∞ 3	∞ *4	∞ 5e5	0/15
SSEABU	2.0(0.6)	1.9(0.3)	2.0(0.5)	1.8(0.2)	1.6(0.3)	1.2(0.1)	1.2(0.1)	115/15	SSEABU	1 1 5(0 5)	2.2(5)	0.89(1)	0 89(0 1)	- 14(1)	21(21)	29(73)	1 2/15
			()	()		()	( )			1 10(0.5)	(-)		0105(011)		21(21)	((**)	
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ
$\frac{\Delta f_{\text{opt}}}{\mathbf{f}^7}$ PSO	1e1 24 11(15)	1e0 324 9.5(14)	1e-1 1171 587(953)	1e-2 1451 475(487)	1e-3 1572 541(513)	1e-5 1572 541(644)	1e-7 1597 533(895)	#succ 15/15 6/15	$\frac{\Delta f_{\text{opt}}}{\mathbf{f19}}$ PSO	1e1 15(30)	1e0 1 3381(3064)	1e-1 242 2450(4336)	1e-2 1.0e5 67(85)	1e-3 1.2e5 60(105)	1e-5 1.2e5 61(69)	1e-7 1.2e5 61(32)	#succ 15/15 0/15
$\frac{\Delta f_{\text{opt}}}{\mathbf{f7}}$ PSO GA	1e1 24 11(15) 49(47)	1e0 324 9.5(14) 35(8)	1e-1 1171 587(953) 57(218)	1e-2 1451 475(487) 245(265)	1e-3 1572 541(513) 524(648)	1e-5 1572 541(644) 524(415)	1e-7 1597 533(895) 523(1024)	#succ 15/15 6/15 5/15	$\frac{\Delta f_{\text{opt}}}{\mathbf{f19}}$ PSO GA	1e1 1 35(30) 35(23)	1e0 1 3381(3064) 1.2e4(7520)	1e-1 242 2450(4336) 700(368)	1e-2 1.0e5 67(85) 68(48)	11(1) 1e-3 1.2e5 60(105) 60(57)	1e-5 1.2e5 61(69) ∞	1e-7 1.2e5 61(32) ∞ 5e5	#succ 15/15 0/15 0/15
$\Delta f_{opt}$ <b>f7</b> PSO GA ABC	1e1 24 11(15) 49(47) 19(30)	1e0 324 9.5(14) 35(8) 16(8)	1e-1 1171 587(953) 57(218) 62(51) + 3	1e-2 1451 475(487) 245(265) 464(514)	1e-3 1572 541(513) 524(648) 957(1649)	1e-5 1572 541(644) 524(415) 957(1331) +4	1e-7 1597 533(895) 523(1024) 1359(2374) +4	#succ 15/15 6/15 5/15 1/15	$\Delta f_{opt}$ <b>f19</b> PSO GA ABC	1e1 1e1 35(30) 35(23) 34(48)	1e0 1 3381(3064) 1.2e4(7520) 2898(1540)	1e-1 242 2450(4336) 700(368) 3826(3344)	1e-2 1.0e5 67(85) 68(48) 69(51) 2 + 2	1e-3 1.2e5 60(105) 60(57) ~	1.2e5 61(69)	1e-7 1.2e5 61(32) $\infty 5e5$ $\infty 5e5$ $\infty + 2$	#succ 15/15 0/15 0/15 0/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC	1e1 24 11(15) 49(47) 19(30) 5.9(3)	1e0 324 9.5(14) 35(8) 16(8) <b>1.9</b> (2)	1e-1 1171 587(953) 57(218) 62(51) 1.4(0.6)* <sup>3</sup>	$     \begin{array}{r}       1e-2 \\       \hline       1451 \\       475(487) \\       245(265) \\       464(514) \\       1.4(1)^{\star 3}     \end{array} $	1e-3 1572 541(513) 524(648) 957(1649) 1.4(0.6)*4	1e-5 1572 541(644) 524(415) 957(1331) 1.4(0.8)*4	1e-7 1597 533(895) 523(1024) 1359(2374) 1.4(1)*4	#succ 15/15 6/15 5/15 1/15 15/15	$\frac{\Delta f_{\text{opt}}}{\mathbf{f19}}$ PSO GA ABC SSEABC	1e1 1e1 135(30) 35(23) 34(48) 247(43)	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(5798)	1e-1 242 2450(4336) 700(368) 3826(3344) 158(101)*	1e-2 1.0e5 67(85) 68(48) 69(51) 2 3.4(3)*2	$     \begin{array}{r}       11.2e5 \\       60(105) \\       60(57) \\       \infty \\       6.0(3)^{\star 2}     \end{array} $	1e-5 1.2e5 61(69) $\infty$ $6.0(3)^{*2}$	$1e-7$ 1.2e5 61(32) $\infty$ 5e5 $\infty$ 5e5 5.9(6)*2	#succ 15/15 0/15 0/15 0/15 0/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC $\Delta f_{opt}$	1e1 24 11(15) 49(47) 19(30) 5.9(3) 1e1	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 1e0	$\frac{1100}{1000}$ $\frac{1100}{1000}$ $\frac{1100}{1000}$ $\frac{11000}{1000}$ $\frac{11000}{1000}$ $\frac{1000}{1000}$ $\frac{1000}{1000}$	1e-2 1451 475(487) 245(265) 464(514) 1.4(1)*3 1e-2 252	1e-3 1572 541(513) 524(648) 957(1649) 1.4(0.6)*4 1e-3	1e-5 1572 541(644) 524(415) 957(1331) 1.4(0.8)*4 1e-5	$1e-7$ $1597$ $533(895)$ $523(1024)$ $1359(2374)$ $1.4(1)^{\pm 4}$ $1e-7$ $127$	#succ 15/15 6/15 5/15 1/15 15/15 #succ	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC $\Delta f_{opt}$	1e1 1e1 135(30) 35(23) 34(48) 247(43) 1e1	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(5798) 1e0 551	1e-1 242 2450(4336) 700(368) 3826(3344) 158(101)*	1e-2 1.0e5 67(85) 68(48) 69(51) 2 3.4(3)*2 1e-2	1.2e5 60(105) 60(57) ∞ 6.0(3)*2 1e-3		$1e-7$ $1.2e5$ $61(32)$ $\infty 5e5$ $\infty 5e5$ $5.9(6)*2$ $1e-7$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 #succ
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO	1e1 24 11(15) 49(47) 19(30) 5.9(3) 1e1 73 13(5)	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 1e0 273 153(4)	$\begin{array}{c} 10.1\\ 1e-1\\ \hline 1171\\ 587(953)\\ 57(218)\\ 62(51)\\ 1.4(0.6)^{\star}3\\ 1e-1\\ \hline 336\\ 201(54) \end{array}$	$1e-2$ $1451$ $475(487)$ $245(265)$ $464(514)$ $1.4(1)*^{3}$ $1e-2$ $372$ $313(18)$	$1e-3 \\ 1572 \\ 541(513) \\ 5524(648) \\ 957(1649) \\ 1.4(0.6) * 4 \\ 1e-3 \\ 391 \\ 467(364) \\ 1e-3 \\ 100 \\$	1e-5 1572 541(644) 524(415) 957(1331) 1.4(0.8)*4 1e-5 410 781(90)	1e-7 1597 533(895) 523(1024) 1359(2374) 1.4(1)*4 1e-7 422 1104(98)	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 7/15	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f20}}$ PSO	1e1 1 35(30) 35(23) 34(48) 247(43) 1e1 16 8.7(4)	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(5798) 1e0 851 3.1(1.0)	1e-1 242 2450(4336) 700(368) 3826(3344) 158(101)* 1e-1 38111 27(17)	1e-2 1.0e5 67(85) 68(48) 69(51) 2 3.4(3)*2 1e-2 51362 20(22)	$11(1)$ $1e-3$ $1.2e5$ $60(105)$ $60(57)$ $\infty$ $6.0(3)^{*2}$ $1e-3$ $54470$ $19(21)$	$ \begin{array}{r}  1e-5 \\  1.2e5 \\  61(69) \\  \infty \\  6.0(3)^{\star 2} \\  1e-5 \\  54861 \\  19(11) \\ \end{array} $	$1e-7$ $1.2e5$ $61(32)$ $\infty 5e5$ $\infty 5e5$ $5.9(6)^{*2}$ $1e-7$ $55313$ $18(23)$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 #succ 14/15 5/15
$\frac{\Delta f_{opt}}{\mathbf{f7}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f8}}$ PSO GA	1e1 24 11(15) 49(47) 19(30) 5.9(3) 1e1 73 13(5) 187(62)	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 1e0 273 153(4) 837(2016)	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ \hline 336 \\ 201(54) \\ \infty \end{array}$	$1e-2$ $1451$ $475(487)$ $245(265)$ $464(514)$ $1.4(1)^{*3}$ $1e-2$ $372$ $313(18)$ $\infty$	$1e-3  1572  541(513)  524(648)  957(1649)  1.4(0.6) * 4  1e-3  391  467(364)  \infty$	$\begin{array}{c} 1e-5 \\ \hline 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e-5 \\ \hline 410 \\ 781(90) \\ \infty \end{array}$	$1e-7$ $1597$ $533(895)$ $523(1024)$ $1359(2374)$ $1.4(1)^{*4}$ $1e-7$ $422$ $1104(98)$ $\infty 5e5$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 7/15 0/15	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f20}}$ PSO GA	1e1 1e1 1 35(30) 35(23) 34(48) 247(43) 1e1 16 8.7(4) 47(51)	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(5798) 1e0 851 3.1(1.0) 21(6)	1e-1           242           2450(4336)           700(368)           3826(3344)           158(101)*           1e-1           38111           27(17)           1.00(0.1)	1e-2 1.0e5 67(85) 68(48) 69(51) 2 3.4(3)*2 1e-2 51362 20(22) 1.0(0.2)	$10.1(1)$ $1e-3$ $1.2e5$ $60(105)$ $60(57)$ $\infty$ $6.0(3)*2$ $1e-3$ $54470$ $19(21)$ $1.3(0.1)$	$1e-5$ 1.2e5 61(69) $\infty$ 6.0(3)*2 1e-5 54861 19(11) 2.6(0.3)	$1e^{-7}$ $1.2e^{-5}$ $61(32)$ $\infty 5e^{-5}$ $5.9(6)^{+2}$ $1e^{-7}$ $55313$ $18(23)$ $5.0(7)$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 #succ 14/15 5/15 11/15
$\frac{\Delta f_{opt}}{\mathbf{f7}}$ PSO GA ABC SSEABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f8}}$ PSO GA ABC	1e1 24 11(15) 49(47) 19(30) 5.9(3) 1e1 73 13(5) 187(62) 6.0(1)	1e0 324 9.5(14) 35(8) 16(8) <b>1.9</b> (2) 1e0 273 153(4) 837(2016) 12(13)	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ \pm 2 \end{array}$	$1e-2$ $1451$ $475(487)$ $245(265)$ $464(514)$ $1.4(1)^{*3}$ $1e-2$ $372$ $313(18)$ $\infty$ $449(875)$ $+3$	$1e^{-3}$ $1e^{-3}$ $1572$ $541(513)$ $524(648)$ $957(1649)$ $1.4(0.6)^{\star 4}$ $1e^{-3}$ $467(364)$ $\infty$ $2510(1785)$ $2510(1785)$	$1e^{-5}$ $1572$ $541(644)$ $524(415)$ $957(1331)$ $1.4(0.8)^{*4}$ $1e^{-5}$ $410$ $781(90)$ $\infty$ $\infty$	$\begin{array}{c} 1e-7 \\ \hline 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{\star}4 \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ \pm 4 \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 7/15 0/15 0/15	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f20}}$ PSO GA ABC	1e1 35(30) 35(23) 34(48) 247(43) 1e1 16 8.7(4) 47(51) 7.2(3)	$\begin{array}{c} 1 \\ 1 \\ 1 \\ 3381(3064) \\ 1.2e4(7520) \\ 2898(1540) \\ 2379(5798) \\ 1e0 \\ \hline \\ 851 \\ 3.1(1.0) \\ 21(6) \\ 1.5(0.7) \\ \star 2 \end{array}$	1e-1           242           2450(4336)           700(368)           3826(3344)           158(101)*           27(17)           1.00(0.1)           0.55(0.5)	1e-2           1.0e5           67(85)           68(48)           69(51)           2           3.4(3)*2           1e-2           20(22)           1.0(0.2)           0.48(0.5)	$\begin{array}{c} 1e-3 \\ \hline 1.2e5 \\ 60(105) \\ 60(57) \\ \infty \\ 6.0(3)^{\star 2} \\ \hline 19(21) \\ 1.3(0.1) \\ 0.58(0.2) \end{array}$	$\begin{array}{c} 1.2(5) \\ 1e-5 \\ \hline 61(69) \\ \infty \\ 6.0(3)^{\star 2} \\ 1e-5 \\ \hline 54861 \\ 19(11) \\ 2.6(0.3) \\ 1.5(2) \end{array}$	$1e-7$ $1.2e5$ $61(32)$ $\infty 5e5$ $\infty 5e5$ $5.9(6) * 2$ $1e-7$ $55313$ $18(23)$ $5.0(7)$ $2.6(2)$	#succ 0/15 0/15 0/15 0/15 0/15 0/15 #succ 14/15 5/15 11/15
$\frac{\Delta f_{opt}}{\mathbf{f7}}$ PSO GA ABC SSEABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f8}}$ PSO GA ABC SSEABC	1e1           24           11(15)           49(47)           19(30)           5.9(3)           1e1           13(5)           187(62)           6.0(1)           4.7(1)	1e0 324 9.5(14) 35(8) 1.6(8) 1.9(2) 1e0 273 153(4) 837(2016) 12(13) 5.6(7)	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \end{array}$	1e-2 1451 475(487) 245(265) 464(514) 1.4(1)*3 1e-2 372 313(18) ∞ 449(875) 14(51)*3	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e-3 \\ \hline 391 \\ 467(664) \\ \infty \\ 2510(1785) \\ 14(9)^{\star 4} \end{array}$	$\begin{array}{c} 1e^{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e^{-5} \\ \hline 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star 4} \end{array}$	$\begin{array}{c} 1e{-7} \\ \hline 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{\star 4} \\ 1e{-7} \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{\star 4} \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 7/15 0/15 0/15 15/15	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f20}}$ PSO GA ABC SSEABC SSEABC	1e1           1e1           35(30)           35(23)           34(48)           247(43)           1e1           16           8.7(4)           47(51)           7.2(3)           2.6.9(3)	$\begin{array}{c} 1 \\ 1 \\ 1 \\ 3381(3064) \\ 1.2e4(7520) \\ 2898(1540) \\ 2379(5798) \\ 1e0 \\ 851 \\ 3.1(1.0) \\ 21(6) \\ 1.5(0.7) \star 2 \\ 12(15) \end{array}$	1e-1           242           2450(4336)           700(368)           3826(3344)           158(101)*           1e-1           38111           27(17)           1.00(0.1)           0.55(0.5)           18(25)	$\begin{array}{r} 1.0 < 5.7 \\ \hline 1.0 = 2 \\ 1.0 = 5 \\ 67(85) \\ 68(48) \\ 69(51) \\ 2 \\ \hline 3.4(3)^{\star} 2 \\ \hline 1e^2 \\ 10(22) \\ 1.0(0.2) \\ 0.48(0.5) \\ 14(31) \\ \end{array}$	$\begin{array}{c} 1.2e5\\ 60(105)\\ 60(57)\\ \infty\\ 6.0(3)^{\star 2}\\ 1e-3\\ 19(21)\\ 1.3(0.1)\\ 0.58(0.2)\\ 13(25)\\ \end{array}$	$\begin{array}{c} 1(c,5) \\ 1c-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ 6.0(3)^{\star 2} \\ 1e-5 \\ 54861 \\ 19(11) \\ 2.6(0.3) \\ 1.5(2) \\ 13(14) \end{array}$	$\begin{array}{c} 1.2e5\\ 1.2e5\\ 61(32)\\ \infty \ 5e5\\ \infty \ 5e5\\ 1e-7\\ 1e-7\\ 18(23)\\ 5.0(7)\\ 2.6(2)\\ 13(14)\\ \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 #succ 14/15 5/15 11/15 15/15 1/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO GA ABC SSEABC $\Delta f_{opt}$	$\begin{array}{c} 1e1 \\ \hline 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 5.9(3) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 4.7(1) \\ 1e1 \\ \end{array}$	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 1e0 273 153(4) 837(2016) 12(13) 5.6(7) 1e0	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ \hline 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ \end{array}$	$\begin{array}{c} 1e-2 \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star 3} \\ 1e-2 \\ \hline 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star 3} \\ 1e-2 \\ \end{array}$	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e-3 \\ \hline 391 \\ 467(664) \\ \mathbf{\infty} \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e-3 \\ \end{array}$	$\begin{array}{c} 1e^{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e^{-5} \\ \hline 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star 4} \\ 1e^{-5} \\ \end{array}$	$\begin{array}{c} 1e{-7} \\ \hline 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{\pm 4} \\ 1e{-7} \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{\pm 4} \\ 1e{-7} \\ \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 7/15 0/15 15/15 #succ 15/15 #succ	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f20}}$ PSO GA ABC SSEABC $\Delta f_{opt}$	1e1           1e1           35(30)           35(23)           34(48)           247(43)           1e1           16           8.7(4)           47(51)           7.2(3) <b>6.9</b> (3)           1e1	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2879(5798) 1e0 851 3.1(1.0) 21(6) 1.5(0.7) * 2 12(15) 1e0	1e-1           242           2450(4336)           700(368)           3826(3344)           158(101)*           1e-1           38111           27(17)           1.00(0.1)           0.55(0.5)           18(25)           1e-1	$\begin{array}{r} 1e{-}2\\ 1e{-}2\\ 67(85)\\ 68(48)\\ 69(51)\\ 2\\ \hline 1e{-}2\\ \hline 51362\\ 20(22)\\ 10(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e{-}2\\ \end{array}$	$\begin{array}{c} 1.2e5\\ 60(105)\\ 60(57)\\ \infty\\ 6.0(3)^{\star 2}\\ 1e-3\\ 19(21)\\ 1.3(0.1)\\ 0.58(0.2)\\ 13(25)\\ 1e-3\\ \end{array}$	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ 6.0(3)^{\star 2} \\ 1e-5 \\ 54861 \\ 19(11) \\ 2.6(0.3) \\ 1.5(2) \\ 13(14) \\ 1e-5 \end{array}$	$\begin{array}{c} 1.2e5\\ 1.2e5\\ 61(32)\\ \infty 5e5\\ \infty 5e5\\ 5.9(6)^{\star}2\\ 1e-7\\ 55313\\ 18(23)\\ 5.0(7)\\ 2.6(2)\\ 13(14)\\ 1e-7\\ \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 14/15 5/15 11/15 15/15 1/15 #succ
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ PSO	$\begin{array}{c} 1e1 \\ & 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 5.9(3) \\ 1e1 \\ & 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 4.7(1) \\ 1e1 \\ & 35 \\ 24(11) \\ \end{array}$	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 1e0 273 153(4) 837(2016) 12(13) 5.6(7) 1e0 127 938(1013)	$\begin{array}{c} 11(35)\\ 11e-1\\ 1171\\ 587(953)\\ 57(218)\\ 62(51)\\ 1.4(0.6)^{\star}3\\ 1e-1\\ 336\\ 201(54)\\ \infty\\ 52(120)\\ 8.7(1.0)^{\star}2\\ 1e-1\\ 214\\ c78(61)\\ \end{array}$	$\begin{array}{c} 16-2 \\ \hline 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star 3} \\ 1e^{-2} \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star 3} \\ 1e-2 \\ 263 \\ 794(1464) \end{array}$	$\begin{array}{c} 1e-3 \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6) \star 4 \\ 1e-3 \\ 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9) \star 4 \\ 1e-3 \\ 300 \\ 1131(1690) \end{array}$	$\begin{array}{c} 1e-5 \\ 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1.4(0.8) \star 4 \\ 1e-5 \\ \hline 410 \\ 781(90) \\ \infty \\ 14(1.0) \star 4 \\ 1e-5 \\ \hline 335 \\ 335 \\ 2363(2310) \\ \hline \end{array}$	$\begin{array}{c} 1e-7 \\ \hline 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{\star}4 \\ \hline 1e-7 \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{\star}4 \\ 1e-7 \\ \hline 369 \\ 2753(1061) \\ \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 0/15 0/15 15/15 #succ 15/15 5/15	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f20}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{\mathbf{f21}}$ PSO	1e1           1           35(30)           35(23)           34(48)           47(43)           1e1           6           8.7(4)           47(51)           7.2(3)           6.9(3)           1e1           2           9.0(2)	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(5798) 1e0 851 3.1(1.0) 21(6) 1.5(0.7)*2 12(15) 1e0 1157 370(541)	1e-1           242           2450(4336)           700(368)           3826(3344)           158(101)*           1e-1           38111           27(17)           1.00(0.1)           0.55(0.5)           18(25)           1e-1           1674           1674	1e-2           1.0e5           67(85)           68(48)           69(51)           2           3.4(3)*2           1e-2           20(22)           1.0(0.2)           0.48(0.5)           14(31)           1e-2           20(22)           1.0(0.2)           0.48(0.5)           14(31)           1e-2           1692           20(270)	$\begin{array}{c} 1.2e5\\ 60(105)\\ 60(57)\\ \infty\\ 6.0(3)^{\star}2\\ 1e^{-3}\\ 54470\\ 19(21)\\ 1.3(0.1)\\ 0.58(0.2)\\ 13(25)\\ 1e^{-3}\\ 1705\\ 258(734)\\ \end{array}$	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ 6.0(3)^{\star}2 \\ 1e-5 \\ 54861 \\ 19(11) \\ 2.6(0.3) \\ 1.5(2) \\ 13(14) \\ 1e-5 \\ 13(14) \\ 1e-5 \\ 1729 \\ 255(50c) \end{array}$	$\begin{array}{c} 1.2e5\\ 1.2e5\\ 61(32)\\ \infty 5e5\\ \infty 5e5\\ 5.9(6)^{\star}2\\ 1e-7\\ 55313\\ 18(23)\\ 5.0(7)\\ 2.6(2)\\ 13(14)\\ 1e-7\\ 13(14)\\ 1e-7\\ 1757\\ 25/214)\end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 14/15 5/15 1/15 15/15 1/15 14/15 14/15 8/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ PSO GA	$\begin{array}{c} 1 \text{e1} \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 5.9(3) \\ 1e1 \\ 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 4.7(1) \\ 1e1 \\ 35 \\ 24(11) \\ 418(128) \end{array}$	$\begin{array}{c} 1e0 \\ \hline 324 \\ 9.5(14) \\ 35(8) \\ 16(8) \\ 1.9(2) \\ 1e0 \\ \hline 273 \\ 153(4) \\ 837(2016) \\ 12(13) \\ 5.6(7) \\ 1e0 \\ \hline 127 \\ 938(1013) \\ 5.6e4(5e4) \end{array}$	$\begin{array}{c} 11c-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1c-1 \\ \hline 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star 2} \\ 1c-1 \\ 1c-1 \\ 214 \\ 678(631) \\ \infty \end{array}$	$\begin{array}{c} 1e-2 \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star 3} \\ 1e-2 \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star 3} \\ 1e-2 \\ 263 \\ 794(1464) \\ \infty \end{array}$	$\begin{array}{c} 11e-3 \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star}4 \\ 1e-3 \\ 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9)^{\star}4 \\ 1e-3 \\ \hline 300 \\ 1131(1699) \\ \infty \end{array}$	$\begin{array}{c} 1e-5 \\ 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e-5 \\ \hline 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star 4} \\ 1e-5 \\ \hline 335 \\ 2363(2310) \\ \infty \end{array}$	$\begin{array}{c} 1e\text{-}7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{\star}4 \\ 1e\text{-}7 \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{\star}4 \\ 1e\text{-}7 \\ \hline 1e\text{-}7 \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 0/15 15/15 #succ 15/15 15/15 0/15 15/15 15/15 0/15 0/15 15/15 15/15 1/15 0/15 15/15 1/15 15/15 0/15 15/15 15/15 15/15	$\frac{\Delta f_{opt}}{\mathbf{f19}}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC GA	$\begin{array}{c} 1e1 \\ 1e1 \\ 1 \\ 35(30) \\ 35(23) \\ 34(48) \\ 247(43) \\ 1e1 \\ 16 \\ 8.7(4) \\ 47(51) \\ 7.2(3) \\ 2.6.9(3) \\ 1e1 \\ 1e1 \\ 41 \\ 2.0(2) \\ 4.6(3) \end{array}$	$\begin{array}{c} 1 \\ 1 \\ 1 \\ 3381(3064) \\ 1.2e4(7520) \\ 2898(1540) \\ \textbf{2379}(5798) \\ 1e0 \\ \hline 851 \\ 3.1(1.0) \\ 21(6) \\ 1.5(0.7)^{\star 2} \\ 12(15) \\ 1e0 \\ \hline 1157 \\ 379(541) \\ 5.5(2) \\ \end{array}$	1e-1           242           2450(4336)           700(368)           3826(3344)           158(101)*           1e-1           27(17)           1.00(0.1)           0.55(0.5)           18(25)           1e-1           1674           262(523)           61(161)	$\begin{array}{c} 1.0e5\\ 67(85)\\ 68(48)\\ 69(51)\\ 20(22)\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 1692\\ 260(370)\\ 68(232)\\ \end{array}$	$\begin{array}{c} 1.c)^{2} \\ 1e^{-3} \\ \hline 1.2e5 \\ 60(105) \\ 60(57) \\ \infty \\ 6.0(3) \\ \star^{2} \\ 1e^{-3} \\ 554470 \\ 19(21) \\ 1.3(0.1) \\ 0.58(0.2) \\ 13(25) \\ 1e^{-3} \\ 1e^{-3} \\ 1705 \\ 258(734) \\ 70(154) \end{array}$	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ 6.0(3)^{\star}2 \\ 1e-5 \\ 54861 \\ 19(11) \\ 2.6(0.3) \\ 1.5(2) \\ 13(14) \\ 1e-5 \\ 1729 \\ 255(506) \\ 139(219) \end{array}$	$\begin{array}{c} 1.e^{-7} \\ 1.e^{-2} \\ 1.2e^{-5} \\ \infty 5e^{-5} \\ 5.9(6)^{\pm 2} \\ 1e^{-7} \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 252(214) \\ 291(292) \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 14/15 5/15 1/15 15/15 1/15 14/15 15/15 1/15 14/15 8/15 14/15 15/15 1/1
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ PSO GA ABC	1e1           24           11(15)           49(47)           19(30) <b>5.9</b> (3)           1e1           73           13(5)           187(62)           6.0(1)           4.7(1)           1e1           35           24(11)           1418(128)           14(12)	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 1e0 273 153(4) 837(2016) 12(13) 5.6(7) 1e0 127 938(1013) 5.6e4(5e4) 69(66) 2	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(93) \\ 572(218) \\ 62(51) \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0) \\ *2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 2 \end{array}$	$\begin{array}{c} 1e-2 \\ \hline 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star 3} \\ 1e-2 \\ \hline 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star 3} \\ 1e-2 \\ \hline 263 \\ 794(1464) \\ \hline 3994(3662) \\ 2 \end{array}$	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 552(648) \\ 957(1649) \\ 1e-3 \\ \hline 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9) * 4 \\ 1e-3 \\ \hline 300 \\ 1131(1699) \\ \infty \\ \infty \\ 14 \end{array}$	$\begin{array}{c} 1e-5 \\ \hline 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1e-5 \\ \hline 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{*4} \\ 1e-5 \\ \hline 335 \\ 2363(2310) \\ \infty \\ \infty \\ 14 \\ 14 \\ 14 \\ 14 \\ 14 \\ 14 \\$	$\begin{array}{c} 1e{\text{-}7} \\ \hline 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{*} 4 \\ 1e{\text{-}7} \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 1e{\text{-}7} \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 148 \\ 1e{\text{-}7} \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 148 \\ 1e{\text{-}7} \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 148 \\ 188 \\$	#succ 15/15 6/15 1/15 15/15 15/15 #succ 15/15 0/15 15/15 #succ 15/15 15/15 0/15 0/15 0/15 0/15	$\frac{\Delta f_{opt}}{f_{19}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f_{20}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f_{21}}$ PSO GA ABC SSCABC GA	1 e1 1 e1 35(30) 35(23) 34(48) 47(43) 1e1 16 8.7(4) 47(51) 7.2(3) 6.9(3) 1e1 41 2.0(2) 41 3.2(2)	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7)^{\star 2}\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 1.8(2)\\ \end{array}$	$\begin{array}{c} 242\\ 2450(4336)\\ 700(368)\\ 3826(3344)\\ 158(101)^{\star}\\ 1e-1\\ 38111\\ 27(17)\\ 1.00(0.1)\\ 0.55(0.5)\\ 18(25)\\ 1e-1\\ 1674\\ 262(523)\\ 61(161)\\ 6.7(8)\\ \end{array}$	$\begin{array}{c} 10-2\\ 1-2\\ \hline 1.0e5\\ 67(85)\\ 68(48)\\ 69(51)\\ 2\\ 3.4(3) * 2\\ 1e-2\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 1692\\ 260(370)\\ 68(232)\\ 10(8)\\ \end{array}$	$\begin{array}{c} 1.c.3 \\ 1.2e5 \\ 60(105) \\ 60(57) \\ \infty \\ 6.0(3)^{\star}2 \\ 1e-3 \\ 54470 \\ 19(21) \\ 1.3(0.1) \\ 0.58(0.2) \\ 13(25) \\ 1e-3 \\ 1705 \\ 258(734) \\ 70(154) \\ 13(14) \\ \end{array}$	$\begin{array}{c} 1.(c5)\\ 1.c-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ 6.0(3)^{\star}2\\ 1e-5\\ 54861\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1729\\ 255(506)\\ 139(219)\\ 84(138)\\ \end{array}$	$\begin{array}{c} 1.e^{-7} \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e^{-7} \\ 55313 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 252(214) \\ 291(292) \\ 265(149) \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 1/15 14/15 1/15 1/15 1/15 1/15 1/15 1/15 8/15 8/15 8/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ PSO GA ABC SSEABC SSEABC $\frac{\Delta f_{opt}}{f9}$	1e1           24           11(15)           49(47)           19(30)           5.9(3)           1e1           73           13(5)           87(62)           6.0(1)           4.7(1)           1e1           35           24(11)           418(128)           9.0(3)	$\begin{array}{c} 1 e0 \\ \hline 324 \\ 9.5(14) \\ 35(8) \\ 16(8) \\ 1.9(2) \\ 1e0 \\ \hline 273 \\ 153(4) \\ 837(2016) \\ 837(2016) \\ 12(13) \\ 5.6(7) \\ 1e0 \\ \hline 127 \\ 938(1013) \\ 5.6e(5e4) \\ 69(66) \\ 11(12)^{\star}3 \end{array}$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \end{array}$	$\begin{array}{c} 1e-2 \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star}3 \\ 1e-2 \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star}3 \\ 1e-2 \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{\star}3 \end{array}$	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\pm 4} \\ 1e-3 \\ 391 \\ 467(364) \\ \infty \\ 12510(1785) \\ 14(9)^{\pm 4} \\ 1e-3 \\ 300 \\ 1131(1699) \\ \infty \\ 15(0.7)^{\pm 4} \end{array}$	$\begin{array}{c} 1e{-5} \\ \hline 1572 \\ 541(644) \\ 524(415) \\ 957(131) \\ 1.4(0.8)^{\pm 4} \\ 1e{-5} \\ 410 \\ 781(90) \\ \infty \\ 14(1.0)^{\pm 4} \\ 1e{-5} \\ 335 \\ 2353(2210) \\ \infty \\ 14(29)^{\pm 4} \end{array}$	$\begin{array}{c} 1e{-7} \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 14(1)^{\star 4} \\ 1e{-7} \\ 422 \\ 1104(98) \\ \infty 5e5 \\ 5e5 \\ 14(8)^{\star 4} \\ 1e{-7} \\ 369 \\ 2753(1061) \\ \infty 5e5 \\ 5e5 \\ 13(17)^{\star 4} \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 0/15 0/15 15/15 #succ 15/15 15/15 15/15 15/15	$\frac{\Delta f_{opt}}{f_{19}}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC ABC SSEABC	1         1           1         1           35(23)         35(23)           35(23)         34(48)           47(43)         1           47(51)         7.2(3)           6.9(3)         1           1         2.0(2)           4.6(3)         3.2(2)           2.1(2)         2.1(2)	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2898(1540) 2379(5798) 1e0 851 3.1(1.0) 21(6) 21(6) 1.5(0.7)*2 12(15) 1e0 1157 379(541) 5.5(2) 1.8(2) 5.0(8)	1e-1         242           2450(4356)         322(457)           382(4344)         158(101)*           1e-1         18111           27(17)         1.00(0.1)           0.550(0.5)         18(25)           1e-1         1674           262(523)         61(161)           6.7(8)         6.7(8)           131(6)         131(16)	1e-2           10e5           67(85)           68(48)           69(51)           3.4(3)*2           1e-2           51362           20(22)           1.0(0.2)           0.48(0.5)           14(31)           1e-2           260(370)           68(232)           10(8)           13(15)	1e-3 1e-3 1e-3 1e-3 54470 19(21) 1.3(0-1) 19(21) 1.3(0-1) 19(21) 1.3(25) 1e-3 19(21) 1.3(25) 1e-3 19(21) 1.3(25) 1e-3 19(21) 1.3(25) 1e-3 10(5) 10(5	$\begin{array}{c} 1.(c5)\\ 1.c-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\star}2\\ 1e-5\\ 54861\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1.729\\ 255(506)\\ 139(219)\\ 84(138)\\ 13(10)\\ \end{array}$	$\begin{array}{c} 1.e-7 \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e-7 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e-7 \\ 1757 \\ 255(214) \\ 291(292) \\ 265(149) \\ 15(22) \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 0/15 1/15 1
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC $\frac{\Delta f_{opt}}{f8}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ PSO ABC SSEABC $\frac{\Delta f_{opt}}{f9}$ SSEABC $\frac{\Delta f_{opt}}{f9}$ SSEABC $\frac{A f_{opt}}{f9}$ SSEABC $\frac{A f_{opt}}{f9}$ SSEABC	1e1           24           11(15)           49(47)           19(30)           1e1           73           13(5)           187(62)           6.0(1)           4.7(1)           1e1           35           24(11)           418(128)           14(12)           9.0(3)           1e1	1e0 324 9.5(14) 35(8) 16(8) 1.9(2) 120 273 133(4) 837(2016) 12(13) 5.6(7) 1e0 127 938(1013) 5.6e4(5c4) 69(66) 11(12)* 3 1e0	$\begin{array}{c} 1 e-1 \\ 1 171 \\ 5 87 (953) \\ 6 2 (51) \\ 1.4 (0.6)^{\star 3} \\ 1e-1 \\ 336 \\ 201 (54) \\ \infty \\ 52 (120) \\ 8.7 (1.0)^{\star 2} \\ 1e-1 \\ 214 \\ 678 (631) \\ \infty \\ 699 (62) \\ 9.0 (9)^{\star 3} \\ 1e-1 \end{array}$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\pm 3} \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\pm 3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{\pm 3} \\ 1e{-2} \\ \end{array}$	$\begin{array}{c} 1e{-3} \\ 1572 \\ 54(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 14(9)^{\star 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ \end{array}$	$\begin{array}{c} 1e{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1e{-5} \\ 410 \\ 781(90) \\ \infty \\ 14(1.0) \\ *4 \\ 1e{-5} \\ 335 \\ 2363(2310) \\ \infty \\ 1e{-5} \\ 1e{-5$	$\begin{array}{c} 1e\text{-}7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 11559(2374) \\ 1.4(1)^{\star 4} \\ 1e\text{-}7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 1104(98) \\ \times 4 \\ 1e\text{-}7 \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{\star 4} \\ 1e\text{-}7 \\ \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 15/15 15/15 0/15 0/1	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC $\Delta f_{opt}$ f20 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f21 f20 f20 f21 f20 f21 f20 f21 f20 f20 f21 f20 f20 f21 f20 f20 f20 f21 f20 f20 f20 f21 f20 f20 f20 f21 f20	1e1           1e1           35(30)           35(23)           34(48)           47(43)           1e1           16           8.7(4)           47(51)           7.2(3)           6.9(3)           1e1           2.0(2)           4.6(3)           3.2(2)           2.1(1)           1e1	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(578) 1e0 851 3.1(1.0) 21(6) 1.5(0.7)★2 12(15) 1e0 1157 379(541) 5.5(2) 1.8(2) 5.0(8) 1e0 295(4) 295(4) 295(4) 295(4) 295(4) 205(	1e-1         242           2450(4336)         382(344)           1e-1         381111           27(17)         100(0.1)           0.050(0.5)         18(25)           1e-1         1674           262(523)         62(161)           61(161)         6.7(8)           13(16)         12(16)           12(13)         12(16)	1e-2           10e5           67(85)           68(48)           69(51)           2           1.0e2           0.48(0.5)           1.4(3)           1e-2           0.48(0.5)           14(31)           1e-2           1692           260(370)           68(232)           13(15)           1e-2	1e-3 1-25 60(105) 60(57) ∞ 6.0(3)*2 1e-3 54470 19(21) 1.3(0.1) 0.58(0.2) 13(25) 1e-3 1705 258(734) 70(154) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(15) 14(14) 13(14) 13(15) 14(14) 13(15) 14(14) 13(15) 14(14) 13(15) 14(14) 13(15) 14(14) 15(15) 15	$\begin{array}{c} 1e-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\star}2\\ 1e-5\\ 54861\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1729\\ 255(506)\\ 139(219)\\ 84(138)\\ 13(10)\\ 1e-5\\ 1a(10)\\ 1e-5\\ 1a(1$	$\begin{array}{c} 1.e^{-7} \\ 1.e^{-2} \\ 1.2e^{-5} \\ 0.5e^{-5} \\ 0.5e^{-5} \\ 0.5e^{-5} \\ 0.5e^{-5} \\ 0.5e^{-5} \\ 1e^{-7} \\ 1e^{-7} \\ 18(23) \\ 18(23) \\ 18(23) \\ 18(23) \\ 18(24) \\ 1e^{-7} \\ 1757 \\ 15(22) \\ 1e^{-7} \\ 1e^{-7} \\ 15(22) \\ 1e^{-7} \\ 1e^$	#succ 15/15 0/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC C GA ABC SSEABC C GA BC SSEABC SSS	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 15,9(3) \\ 1e1 \\ \hline 75 \\ 157(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 147(1) \\ 1e1 \\ \hline 35 \\ 24(11) \\ 418(128) \\ 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 14 \\ 124 \\ 141(21) \\ 9.0(3) \\ 1e1 \\ \hline 349 \\ 1244(416) \\ \hline 141(416) \\$	$\begin{array}{c} 1 e0 \\ 324 \\ 9.5(14) \\ 35(8) \\ 1.9(2) \\ 1 e0 \\ 273 \\ 155(4) \\ 837(2016) \\ 12(13) \\ 5.64(5e4) \\ 69(66) \\ 11(12) \\ 938(1012) \\ 1e0 \\ 11(2) \\ 5.6e4(5e4) \\ 69(66) \\ 326(14e0) \\ 1e0 \\ 100 \\ 236(14e0) \\ 100 \\ 236(14e0) \\ 100 \\ 236(14e0) \\ 100 \\ $	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star 2} \\ 1e-1 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star 3} \\ 1e-1 \\ 574 \\ 574 \\ 1e-1 \\ 574 \\ 5$	$\begin{array}{c} 1e-2 \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{*3} \\ 1e-2 \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{*3} \\ 1e-2 \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{*3} \\ 1e-2 \\ \infty \\ 607 \\ \end{array}$	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e-3 \\ \infty \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e-3 \\ \infty \\ \infty \\ 15(0.7)^{\star 4} \\ 1e-3 \\ \end{array}$	$\begin{array}{c} 1e-5 \\ 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1.4(0.8)^{\star}4 \\ 1e-5 \\ \hline \\ 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star}4 \\ 1e-5 \\ \hline \\ 335 \\ 2363(2310) \\ \infty \\ 14(29)^{\star}4 \\ 1e-5 \\ \hline \\ 829 \\ \hline \end{array}$	$\begin{array}{c} 1e-7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 11559(2374) \\ 1.4(1)^{*}4 \\ 1e-7 \\ 422 \\ 1104(98) \\ \infty \ 5e5 \\ \infty \ 5e5 \\ 14(8)^{*}4 \\ 1e-7 \\ 369 \\ 2753(1061) \\ \infty \ 5e5 \\ 13(17)^{*}4 \\ 1e-7 \\ 880 \\ \infty \ 5e5 \\ \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 #succ 15/15 5/15 0/15 15/15 5/15 0/15 5/15 0/15 15/15 5/15	$\frac{\Delta f_{opt}}{f_{19}}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC $\frac{\Delta f_{opt}}{f_{21}}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f_{22}}$ PSO	$\begin{array}{c} 1 \text{ sc}(3) \\ 1 \text{ sc}(3) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 47(43) \\ 1 \text{ sc}(1) \\ 47(43) \\ 1 \text{ sc}(1) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ sc}(1) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ sc}(2) \\ 2.0(2) \\ 2.0(2) \\ 2.0(2) \\ 1 \text{ sc}(2) \\ 2.0(2) \\ 1 \text{ sc}(2) \\ 2.0(2) \\ 1 \text{ sc}(2) \\ 1 \text{ sc}(2$	$\begin{array}{c} 1e0\\ 1\\ 381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7) \star^2\\ 12(15)\\ 12(15)\\ 12(15)\\ 12(15)\\ 15.5(2)\\ 1.8(2)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 386\\ 326(1296)\\ \end{array}$	1e-1 242 2450(436) 700(566) 382c(3344) 158(101)* 1e-1 33111 27(17) 1.00(0.1) 0.55(0.5) 18(25) 1e-1 1674 262(253) 16(161) 6.7(6) 13(16) 16-1 938 469(534)	$\begin{array}{c} 10-2\\ 1-2\\ \hline 1.0e5\\ 67(85)\\ 69(51)\\ 20(22)\\ 1-2\\ \hline 51362\\ 20(22)\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ \hline 1692\\ 260(370)\\ 68(232)\\ 10(8)\\ 13(15)\\ 1e-2\\ \hline 980\\ 450(102)\\ \hline \end{array}$	$\begin{array}{c} 1e^{-3} \\ 1e^{-3} \\ e^{-3} \\ e^{$	$\begin{array}{c} 1.2 \\ 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ \infty \\ 6.0(3)^{\star}2 \\ 1e-5 \\ 1.5(2) \\ 1.5(2$	$\begin{array}{c} 1.e-7 \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e-7 \\ 5.5313 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e-7 \\ 1757 \\ 252(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e-7 \\ 1068 \\ 422(704) \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 1/15 15/15 15/15 1/15 15/15 1/15 8/15 8/15 1/2/15 8/15 1/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA GA CA SSEABC CA SSEABC GA GA GA CA SSEABC SSEABC GA CA SSEABC SSEABC SSEABC GA CA SSEABC SSEABC SSEABC SSEABC GA CA SSEABC GA GA GA GA GA GA GA GA GA GA GA GA GA	1e1           24           11(15)           49(47)           19(30)           5.9(3)           1s(5)           187(62)           6.0(1)           4.7(1)           1st           24(11)           35           24(11)           14(12)           9.0(3)           1e1           349           1741(4116)           2375(3287)	$\begin{array}{c} 1 e0 \\ \hline 324 \\ 9.5(14) \\ 35(8) \\ 1.9(2) \\ 1 e0 \\ \hline 837(2016) \\ 12(13) \\ 5.6(7) \\ 1 e0 \\ 127 \\ 938(1013) \\ 5.6e4(5e4) \\ 99(66) \\ 11(12)^{*}3 \\ 1 e0 \\ 100 \\ 3259(46) \\ \hline 500 \\ 3259(46) \\ 100 \\ 3259(46) \\ 100 \\ 3259(46) \\ 100 \\ 10$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ \hline \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 1e-1 \\ \hline \\ 574 \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 1e-2 \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star 3} \\ 1e-2 \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star 3} \\ 1e-2 \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 1e-2 \\ 1e-2 \\ 607 \\ \infty \\ \infty \end{array}$	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star}(4) \\ 1e-3 \\ \hline \infty \\ 2510(1785) \\ 14(9)^{\star}(4) \\ 1e-3 \\ \hline 300 \\ 1131(1699) \\ \infty \\ \infty \\ 15(0.7)^{\star}(4) \\ 1e-3 \\ \hline \infty \\ 626 \\ \hline \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 1e-5 \\ \hline 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e-5 \\ \hline 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star 4} \\ 1e-5 \\ \hline 335 \\ 2363(2310) \\ \infty \\ \infty \\ 14(129)^{\star 4} \\ 1e-5 \\ \hline 829 \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 1e{\text{-}7} \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{\star} 4 \\ 1e{\text{-}7} \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{\star} 4 \\ 1e{\text{-}7} \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{\star} 4 \\ 1e{\text{-}7} \\ \hline 880 \\ \infty 5e5 \\ \infty 5e5 \\ \end{array}$	#succ 15/15 6/15 5/15 1/15 15/15 15/15 15/15 15/15 0/15 0/15 15/15 5/15 15/15 15/15 15/15 0/15 15/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC SSEABC $\frac{\Delta f_{opt}}{f20}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f21}$ PSO GA ABC SSEABC $\frac{\Delta f_{opt}}{f22}$ PSO GA GA GA	$\begin{array}{c} 1 \text{ sc}(3) \\ 1 \text{ sc}(3) \\ 35(23) \\ 33(23) \\ 33(23) \\ 33(48) \\ 47(43) \\ 47(43) \\ 47(51) \\ 7.2(3) \\ 47(51) \\ 7.2(3) \\ 4.7(4) \\ 4.7(51) \\ 7.2(3) \\ 1 \text{ sc} \\ 4.7(4) \\ 4.6(3) \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ sc} \\ 71 \\ 2.6(2) \\ 6.0(4) \end{array}$	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ 1e0\\ 1.5(0.7)*2\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 326(1296)\\ 18(13)\\ \end{array}$	1e-1           242           2450(4336)           700(368)           382c(3344)           158(101)*           1e-1           38111           27(17)           1.00(0.1)           0.55(0.5)           18(25)           1e-1           1674           262(523)           61(161)           6.7(8)           13(16)           1e-1           938           469(334)           387(402)	$\begin{array}{c} 10-5\\ 1-2\\ \hline 1.0e5\\ 67(85)\\ 69(51)\\ 29(51)\\ 20(22)\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 1692\\ 260(370)\\ 68(232)\\ 10(8)\\ 13(15)\\ 116-2\\ 980\\ 450(1022)\\ 458(116)\\ 110(22)\\ 648(116)\\ 110(22)\\ 1$	$\begin{array}{c} 1e^3 \\ 1e^3 \\ 1.2e5 \\ 60(105) \\ 60(67) \\ \infty \\ 6.0(3)^{*2} \\ 1e^3 \\ 54470 \\ 19(21) \\ 1.3(0.1) \\ 0.58(0.2) \\ 113(25) \\ 1e^3 \\ 1005 \\ 13(14) \\ 1$	$\begin{array}{c} 1.2 + 5\\ 1.2 +$	$\begin{array}{c} 1.e^{-7} \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e^{-7} \\ 1e^{-7} \\ 55313 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 252(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e^{-7} \\ 1068 \\ 422(704) \\ \infty 5e5 \end{array}$	#succ 15/15 0/15 0/15 0/15 0/15 0/15 14/15 5/15 11/15 15/15 11/15 8/15 8/15 8/15 12/15 14/15 8/15 0/15
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC C ABC SSEABC C AFopt f9 PSO GA ABC SSEABC SSEABC C Afopt f10 PSO GA ABC	1e1 24 11(15) 49(47) 19(30) 15.9(3) 1e1 73 13(5) 187(62) 6.0(1) 4.7(1) 1e1 35 24(11) 1418(128) 14(12) 9.0(3) 1e1 349 1741(4116) 2375(3287) 2.1e4(24)	$\begin{array}{c} 1 e0 \\ 324 \\ 9.5(14) \\ 9.5(14) \\ 35(8) \\ 16(8) \\ 1.9(2) \\ 1e0 \\ 273 \\ 123(4) \\ 837(2016) \\ 12(13) \\ 5.6(7) \\ 1e0 \\ 127 \\ 938(1013) \\ 5.6(5c4) \\ 69(66) \\ 11(12)^* \\ 3259(4409) \\ \infty \\ \infty \end{array}$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 1e-1 \\ 1e-1 \\ 0 \\ \infty \\ \infty \\ 0 \\ \infty \\ \infty \\ \infty \\ 0 \\ 0$	$\begin{array}{c} 1e-2 \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{\star}3 \\ 1e-2 \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{\star}3 \\ 1e-2 \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{\star}3 \\ 1e-2 \\ 607 \\ \infty \\ $	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\pm 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 14(9)^{\pm 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ 15(0.7)^{\pm 4} \\ 1e{-3} \\ 626 \\ \infty \\ \infty \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 1e{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e{-5} \\ 410 \\ \infty \\ 1e{-5} \\ 14(1.0)^{\star 4} \\ 1e{-5} \\ 335 \\ 2353(2210) \\ \infty \\ 14(29)^{\star 4} \\ 1e{-5} \\ 829 \\ \infty \\ $	$\begin{array}{c} 1e-7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 14(1)^{\star 4} \\ 1e-7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{\star 4} \\ 1e-7 \\ 2753(1061) \\ \infty 5e5 \\ 13(17)^{\star 4} \\ 1e-7 \\ 1e-7 \\ \infty 5e5 \\ \end{array}$	#succ 15/15 5/15 1/15 15/15 15/15 15/15 0/15 5/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA	1         1           1         1           35(23)         35(23)           34(48)         47(43)           47(43)         16           8.7(4)         47(51)           7.2(3)         6.9(3)           1e1         1           2.0(2)         1           1e1         1           2.0(2)         2.1(1)           1e1         1           2.0(2)         2.2(1)           1e1         1           1e1         2.6(2)           71         2.6(2)           71         2.6(2)           71         2.6(2)           71         2.6(2)	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2898(1540)\\ 1.26(7598)\\ 1e0\\ \hline \\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7)^{\star 2}\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ \hline \\ 1.8(2)\\ 5.0(8)\\ 1e0\\ \hline \\ 326(1296)\\ 18(13)\\ 7.6(13)\\ \hline \end{array}$	1e-1 242 2450(436) 352(434) 158(101)* 1e-1 381111 27(17) 1.00(0.1) 0.55(0.5) 18(25) 1e-1 1674 262(52) 61(161) 6.7(8) 13(16) 938 460(534) 938	$\begin{array}{c} 1.0+5\\ 1.0+5\\ 6.7(85)\\ 6.8(48)\\ 6.9(51)\\ 2\\ 3.4(3) \times 2\\ 1e-2\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 1692\\ 260(370)\\ 6.8(232)\\ 10(8)\\ 13(15)\\ 1e-2\\ 980\\ 450(1022)\\ 648(1160)\\ 12\\ 237(384)\\ 980\\ 980\\ 980\\ 980\\ 980\\ 980\\ 980\\ 980$	$\begin{array}{c} 1e^{-3} \\ 1e^{-3} \\ 1.2e5 \\ 60(15) \\ 60(57) \\ \infty \\ 6.0(3)^{*2} \\ 1e^{-3} \\ 54470 \\ 19(21) \\ 1.3(21) \\ 1.2(3) \\ 1.2(3) \\ 1.2(3) \\ 1.2(5) \\ 1.2$	$\begin{array}{c} 1.(c5)\\ 1.c-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\pm 2}\\ 1e-5\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1729\\ 255(506)\\ 139(219)\\ 84(138)\\ 13(10)\\ 1e-5\\ 1040\\ 429(726)\\ 6832(1e4)\\ 3312(2932)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 22(292)\\ 2$	$\begin{array}{c} 1.e-7 \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e-7 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e-7 \\ 13(14) \\ 1e-7 \\ 1757 \\ 255(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e-7 \\ 1068 \\ 422(704) \\ \infty 5e5 \\ 6897(4331) \\ 0 \\ 0 \\ 0 \\ 585 \\ 1008 \\ $	#succ 15/15 0/15 0/15 0/15 0/15 14/15 5/15 11/15 15/15 11/15 #succ 14/15 8/15 8/15 12/15 14/15 0/
$\frac{\Delta f_{opt}}{f7}$ PSO GA ABC SSEABC QG ABC SSEABC QG ABC SSEABC QG AABC SSEABC QG AABC SSEABC QG AABC SSEABC SSEABC SSEABC	1e1 24 11(15) 49(47) 19(30) 1e1 73 13(5) 187(62) 6.0(1) 1e1 35 24(11) 1418(128) 14(12) 9.0(3) 1e1 9.0(3) 1e1 2375(2387) 2.1e4(2e4) 3.5(1)*4	1e0 324 9.5(14) 9.5(14) 16(8) 1.9(2) 1e0 273 153(4) 837(2016) 12(13) 5.6(7) 1e0 127 338(1013) 5.6e4(5e4) 69(66) 11(12) <sup>+3</sup> 1e0 500 3259(4409) ∞ ∞ 3.1(0.3)	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 9.0(9)^{\star}3 \\ 1e-1 \\ 574 \\ \infty \\ \infty \\ \infty \\ \star 4 \\ 3.0(0.1)^{\star} \end{array}$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{*3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(36c2) \\ 14(0.8)^{*3} \\ 1e{-2} \\ 607 \\ \infty \\ 4 \\ 3.0(0.4)^{*6} \end{array}$	$\begin{array}{c} 1e{-3} \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 14(9)^{\star 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 626 \\ \infty \\ \infty \\ 3.1(0.2)^{\star 4} \end{array}$	$\begin{array}{c} 1e{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1e{-5} \\ 410 \\ 781(90) \\ \infty \\ 1e{-5} \\ 335 \\ 2363(2310) \\ \infty \\ 1e{-5} \\ 829 \\ \infty \\ \infty \\ 2.5(0.2) \\ *4 \\ \end{array}$	$\begin{array}{c} 1e\text{-}7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 11359(2374) \\ 1.4(1)^{\star 4} \\ 1e\text{-}7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{\star 4} \\ 1e\text{-}7 \\ 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{\star 4} \\ 1e\text{-}7 \\ 1e\text{-}7 \\ 880 \\ \infty 5e5 \\ \infty 5e5 \\ 2.5(0.2)^{\star 4} \end{array}$	#succ           15/15           6/15           5/15           1/15           #succ           15/15           0/15           0/15           15/15           5/15           15/15           5/15           0/15	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC SSEABC $\Delta f_{opt}$ f20 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f21 PSO GA ABC SSEABC $\Delta f_{opt}$ f22 PSO GA ABC SSEABC SSEABC $\Delta f_{opt}$ f22 PSO GA ABC SSEABC $\Delta f_{opt}$ f22 PSO GA ABC SSEABC $\Delta f_{opt}$ f22 PSO GA ABC SSEABC AC AC AC AC AC AC AC AC AC A	$\begin{array}{c} 1 \text{ set} \\ 1 \text{ let} \\ 1 \\ 35(30) \\ 35(23) \\ 37(43) \\ 47(43) \\ 1 \text{ let} \\ 1 \\ 47(43) \\ 1 \\ 47(51) \\ 7.2(3) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \\ 1 \\ 2.6(2) \\ 2.1(1) \\ 1 \\ 2.6(2) \\ 2.1(1) \\ 1 \\ 1 \\ 2.6(2) \\ 5.1(4) \\ 3.2(0.6) \\ 1 \\ 1 \\ 2.6(2) \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ $	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(578)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7) \star 2\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 336\\ 326(1296)\\ 18(13)\\ 7.6(13)\\ 40(112)\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0$	1e-1         242           2450(4336)         326(354)           158(101)*         158(101)*           16-1         38111           27(17)         1.00(0.1)           0.550(5.5)         18(25)           1e-1         1674           262(523)         64(161)           6.7(8)         6.7(8)           938         469(534)           37(402)         358(55)           51(51)         10.1	1e-2           1.0e5           67(85)           68(48)           69(51)           2.3.4(3) * 2           1e-2           20(22)           1.0(0.2)           0.48(0.5)           14(31)           1e-2           260(370)           68(232)           10(8)           13(15)           1e-2           980           450(1022)           648(1160)           237(384)           60(94)           12,2	$\begin{array}{c} 1e^{-3} \\ 1.2e5 \\ 60(105) \\ 60(57) \\ \infty \\ 5.60(3) \\ *^2 \\ 1e^{-3} \\ 5.4470 \\ 19(21) \\ 1.3(0,1) \\ 0.58(0,2) \\ 13(25) \\ 1e^{-3} \\ 1705 \\ 258(734) \\ 700(154) \\ 13(13) \\ 1258(734) \\ 13(13) \\ 1238(734) \\ 13(13) \\ 1008 \\ 439(1426) \\ 439(173) \\ 374(436) \\ 68(66) \\ 10.2$	$\begin{array}{c} 1e-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\pm}2\\ 1e-5\\ 54861\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1729\\ 255(506)\\ 139(219)\\ 84(138)\\ 13(10)\\ 1e-5\\ 12(10)\\ 12$	$\begin{array}{c} 1.e^{-7} \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\pm}2 \\ 1e^{-7} \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 252(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e^{-7} \\ 1068 \\ 422(704) \\ \infty 5e5 \\ 6897(4331) \\ 93(201) \\ 1e^{-7} \\ 1068 \\ 1e^{-7} \\ 1e^{-$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           0/15           10/15           11/15           11/15           15/15           11/15           15/15           11/15           15/15           11/15           14/15           8/15           8/15           8/15           12/15           0/15           0/15           0/15           6/15
Afopt f7 PSO GA ABC SSEABC SSEABC GA ABC SSEABC ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 1e1 \\ \hline 35 \\ 24(11) \\ 418(128) \\ 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 349 \\ 174(4116) \\ 2375(3287) \\ 2.1e4(2e4) \\ 3.5(1)^{\star}4 \\ 1e1 \end{array}$	1e0 324 9.5(14) 16(3) 16(3) 1.9(2) 12(3) 153(4) 837(2016) 12(13) 5.6(7) 120 127 127 127 127 127 127 127 127	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ 336 \\ 201(54) \\ 52(120) \\ 8.7(1.0)^{\star 2} \\ 1e-1 \\ 214 \\ 678(631) \\ 699(628) \\ 9.0(9)^{\star 3} \\ 1e-1 \\ \end{array}$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 4475(487) \\ 245(265) \\ 464(514) \\ 1e{-2} \\ 1e{-2} \\ 313(18) \\ 449(875) \\ 14(31)^{*3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{*3} \\ 1e{-2} \\ \hline \\ 607 \\ \infty \\ e{-4} \\ 3.0(0.4)^{*4} \\ 1e{-2} \\ \end{array}$	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 14(9)^{\star 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ \infty \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 626 \\ \infty \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 12(0.2)^{\star 4} \\ 12(0.2$	$\begin{array}{c} 1e-5 \\ \hline 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1e-5 \\ \hline 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{*4} \\ 1e-5 \\ \hline 335 \\ 2363(2310) \\ \infty \\ 1e-5 \\ \hline 829 \\ \infty \\ 2.5(0.2)^{*4} \\ 1e-5 \\ \hline \end{array}$	$\begin{array}{c} 1e\text{-}7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 11559(2374) \\ 1.4(1)^{*4} \\ 1e\text{-}7 \\ 422 \\ 1104(98) \\ \infty \ 5e5 \\ \infty \ 5e5 \\ 5e5 \\ \infty \ 5e5 $	#succ 15/15 5/15 5/15 1/15 15/15 15/15 #succ 15/15 5/15 0/15 15/15 #succ 0/15 0/15 0/15 0/15 0/15 0/15 15/15 #succ 15/15 0/15 15/15	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC SSEABC SSEABC ABC SSEABC ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC ABC C ACfopt f21 PSO GA ABC SSEABC ABC ABC F20 PSO GA ABC SSEABC ABC F20 PSO GA ABC SSEABC C AC ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC F20 PSO GA ABC SSEABC C SSEABC C SSEABC ABC PSO GA ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC C SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC SSEABC C SSEABC C SSEABC SSEABC C SSEABC SSEABC C SSEABC C SSEABC SSEABC C SSEABC SSEABC SSEABC C SSEABC SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC SSEABC C SSEABC C SSEABC SSEABC C SSEABC C SSEABC C SSEABC C SSEABC C SSEABC SSSEABC SSSEABC SSS	$\begin{array}{c} 1 \text{ cs}(3) \\ 1 \text{ cs}(3) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 47(43) \\ 1 \text{ cs} \\ 1 \text{ cs} \\ 47(51) \\ 7.2(3) \\ 47(51) \\ 7.2(3) \\ 47(51) \\ 6.9(3) \\ 1 \text{ cs} \\ 6.9(3) \\ 1 \text{ cs} \\ 6.9(3) \\ 1 \text{ cs} \\ 1 \text{ cs} \\ 2.0(2) \\ 4.6(3) \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ cs} \\ 1 \text{ cs} \\ 2.0(2) \\ 2.1(1) \\ 1 \text{ cs} \\ 1 \text{ cs} \\ 2.0(2) \\ 2.1(1) \\ 1 \text{ cs} \\ 1 \text{ cs} \\ 2.0(2) \\ 2.1(1) \\ 1 \text{ cs} \\ 1  c$	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(578)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7)^{\star}2\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 326(1296)\\ 18(13)\\ 7.6(13)\\ 40(112)\\ 1e0\\ 518\end{array}$	1e-1           242           2450(4336)           382(6344)           158(101)*           16-1           383111           27(17)           16-1           383111           27(17)           16-1           383111           27(17)           16-1           383111           27(17)           16-1           1674           262(523)           61(161)           6.7(8)           13(16)           1e-1           938           469(534)           337(402)           51(51)           1e-1	1e-2           10e5           67(85)           68(48)           69(51)           2           3.4(3)*2           1e-2           10(0.2)           0.48(0.5)           14(31)           1e-2           260(370)           68(232)           10(8)           13(15)           1e-2           237(384)           60(94)           1e-2	1e-3 1.2e5 60(15) ∞ 6.0(3)*2 1e-3 54470 19(21) 1.3(0.1) 0.58(0.2) 13(25) 16-3 1705 258(734) 70(154) 13(13) 13(13) 13(13) 13(14) 13(15) 16(14) 13	$\begin{array}{c} 1e-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\star}2\\ 1e-5\\ 54861\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1729\\ 13(14)\\ 1e-5\\ 1040\\ 429(726)\\ 6832(1e4)\\ 3312(2932)\\ 81(88)\\ 1e-5\\ 33030\\ \end{array}$	$\begin{array}{c} 1.e^{-7} \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e^{-7} \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 252(214) \\ 291(292) \\ 263(149) \\ 115(22) \\ 1e^{-7} \\ 1068 \\ 422(704) \\ \infty 5e5 \\ 6897(4331) \\ 93(201) \\ 1e^{-7} \end{array}$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           10/15           11/15           15/15           11/15           15/15           11/15           15/15           11/15           14/15           8/15           12/15           8/15           0/15           0/15           6/15           15/15
Afopt f7 PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC CA ABC SSEABC SSEABC SSEABC CA ABC SSEABC	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 15,9(3) \\ 1e1 \\ 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 141(12) \\ 141(1$	$\begin{array}{c} 1 e0 \\ 324 \\ 9.5(14) \\ 9.5(14) \\ 160 \\ 1.9(2) \\ 1e0 \\ 773 \\ 153(4) \\ 837(2016) \\ 12(13) \\ 5.5(4) \\ 5.6e4(5e4) \\ 69(66) \\ 11(12)^{*} \\ 38(1013) \\ 1e0 \\ 1e0 \\ \infty \\ \infty \\ 3.1(0.3) \\ 1e0 \\ 202 \\ 255(14) \\ \end{array}$	$\begin{array}{c} 1e-1 \\ \hline 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ \hline 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ \hline 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 1e-1 \\ \hline 574 \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 1e-1 \\ \hline 763 \\ 124 \\ (0,0,1)^{\star}1 \\ 1e-1 \\ \hline 763 \\ 126 \\ (0,0,1)^{\star}1 \\ 1e-1 \\ \hline 763 \\ 126 \\ (0,0,1)^{\star}1 \\ 1e-1 \\ \hline 763 \\$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{*3} \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{*3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{*3} \\ 1e{-2} \\ 607 \\ \infty \\ \infty \\ 43.0(0.4)^{*4} \\ 1e{-2} \\ 977 \\ 140(27) $	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e{-3} \\ \hline \\ 300 \\ 1131(1699) \\ \infty \\ \infty \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ \hline \\ 626 \\ \infty \\ \infty \\ 4 \\ 3.1(0.2)^{\star 4} \\ 1e{-3} \\ \hline \\ 1177 \\ 164(e^2) \\ \hline \end{array}$	$\begin{array}{c} 1e-5 \\ 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1e-5 \\ \hline \\ 410 \\ 781(90) \\ \infty \\ \infty \\ \infty \\ 14(1.0)^{*}4 \\ 1e-5 \\ \hline \\ 335 \\ 2363(2310) \\ \infty \\ \infty \\ 14(29)^{*}4 \\ 1e-5 \\ \hline \\ 829 \\ \infty \\ \infty \\ 2.5(0.2)^{*}4 \\ 1e-5 \\ \hline \\ 1e-5 \\ \hline \\ 242(170) \\ \hline \end{array}$	$\begin{array}{c} 1e{\text{-}7} \\ 1597 \\ 533(895) \\ 523(1024) \\ 11559(2374) \\ 1e{\text{-}7} \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{*}4 \\ 1e{\text{-}7} \\ 1e{\text{-}7} \\ 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{*}4 \\ 1e{\text{-}7} \\ 880 \\ \infty 5e5 \\ \infty $	#succ 15/15 5/15 5/15 1/15 1/15 1/15 1/15 15/15 15/15 5/15 0/15 15/15 0/15 15/15 0/15 0/15 15/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15 0/15 15/15	Afopt fi9 PSO GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC AC 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        1e-1           1674           262(523)           16(161)           6.7(8)           13(16)           1e-1           938           469(534)           387(402)           358(55)           51(51)           1e-1           14249           243(189)	$\begin{array}{c} 10-2\\ 1-2\\ 1.0e5\\ 67(85)\\ 69(51)\\ 29(22)\\ 1-2\\ 20(22)\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 1692\\ 260(370)\\ 68(232)\\ 10(8)\\ 13(15)\\ 1e-2\\ 980\\ 450(1022)\\ 648(1160)\\ 1237(384)\\ 60(94)\\ 1e-2\\ 27(890\\ \infty\end{array}$	$\begin{array}{c} 1e^{-3} \\ 1e^{-3} \\ 60(15) \\ 60(3)^{*2} \\ 1e^{-3} \\ \hline \\ 54470 \\ 19(21) \\ 0.58(0.2) \\ 13(25) \\ 1e^{-3} \\ 1005 \\ 13(25) \\ 1e^{-3} \\ 13(13) \\ 13(14) \\ 13(15) \\ 13(15) \\ 10(16) \\ 1$	$\begin{array}{c} 1e-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\star}2\\ 1e-5\\ 54861\\ 19(11)\\ 2.6(0.3)\\ 1.5(2)\\ 13(14)\\ 1e-5\\ 1729\\ 255(506)\\ 139(219)\\ 84(138)\\ 1e-5\\ 1040\\ 429(726)\\ 6832(1e4)\\ 3312(2932)\\ 881(88)\\ 1e-5\\ 33030\\ \infty\end{array}$	$\begin{array}{c} 1.e-7 \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e-7 \\ 5.3313 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e-7 \\ 1757 \\ 252(214) \\ 252(214) \\ 252(214) \\ 252(214) \\ 252(214) \\ 252(214) \\ 252(214) \\ 252(214) \\ 16-7 \\ 1068 \\ 422(704) \\ \infty 5e5 \\ 6897(4331) \\ 93(201) \\ 1e-7 \\ 34256 \\ \infty 5e5 \\ \end{array}$	#succ           15/15           0/15           0/15           0/15           0/15           11/15           5/15           11/15           #succ           14/15           8/15           8/15           14/15           8/15           0/15           6/15           0/15           6/15           15/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
$\frac{\Delta f_{opt}}{f7}$ $\frac{\Delta f_{opt}}{f7}$ $\frac{\delta f_{opt}}{f8}$ $\frac{\delta f_{opt}}{f8}$ $\frac{\delta f_{opt}}{f8}$ $\frac{\delta f_{opt}}{f9}$ $\frac{\delta f_{opt}}{f10}$ $\frac{\delta f_{opt}}{f10}$ $\frac{\delta f_{opt}}{f11}$	$\begin{array}{c} 1e1 \\ \hline 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 5.9(3) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 4.7(1) \\ 187(62) \\ 6.0(1) \\ 4.7(1) \\ 1418(128) \\ 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 1418(128) \\ 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 1418(128) \\ 14(16) \\ 2375(3287) \\ 1e1 \\ 143 \\ 335(1814) \\ 338(1814) \\ 338(1814) \\ 338(1814) \\ \end{array}$	$\begin{array}{c} 1 e0 \\ \hline 324 \\ 9.5(14) \\ 35(8) \\ 1.9(2) \\ 1 e0 \\ \hline 273 \\ 153(4) \\ 153(4) \\ 153(4) \\ 12(13) \\ 5.6(7) \\ 12(13) \\ 5.6(7) \\ 12(13) \\ 5.6(7) \\ 12(13) \\ 5.6(45) \\ 10(13) \\ 5.6(45) \\ 11(12) \\ 40(13) \\ 5.6(45) \\ 11(12) \\ 5.6(45) \\ 11(12) \\ 5.6(45) \\ 11(12) \\ 5.6(45) \\ 10(13) \\ 5.6(45) \\ 10(13) \\ 5.6(45) \\ 10(13) \\ 5.6(45) \\ 10(13) \\ 10$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ \hline \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star 2} \\ 1e-1 \\ \hline \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star 3} \\ 1e-1 \\ \hline \\ 574 \\ 9.0(9)^{\star 4} \\ 3.0(0.1)^{\star} \\ 1e-1 \\ \hline \\ 763 \\ 123(68) \\ 9351(1e4) \\ \end{array}$	$\begin{array}{c} 1e{-2} & & \\ 1451 & & \\ 475(487) & 245(255) & \\ 4245(255) & & \\ 464(514) & 1.4(1)^{\star 3} & \\ 1e{-2} & & \\ 372 & & \\ 313(18) & & \\ \infty & & \\ 449(875) & & \\ 14(51)^{\star 3} & \\ 1e{-2} & & \\ 263 & & \\ 794(1464) & & \\ \infty & & \\ 3994(3662) & & \\ 14(64) & & \\ \infty & & \\ 3994(3662) & & \\ 1e{-2} & & \\ 607 & & \\ \infty & & \\ \infty & & \\ 4 & & \\ 3.0(0.4)^{\star 4} & \\ 1e{-2} & & \\ 977 & \\ 140(37) & & \\ \infty & & \\ \end{array}$	$\begin{array}{c} 1e{-3} \\ \hline 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star}(4) \\ 1e{-3} \\ \hline \infty \\ 2510(1785) \\ 14(9)^{\star}(4) \\ 1e{-3} \\ \hline 300 \\ 1131(1699) \\ \hline \infty \\ \infty \\ 15(0.7)^{\star}(4) \\ 1e{-3} \\ \hline 626 \\ \hline \infty \\ 4 \\ 3.1(0.2)^{\star}(4) \\ 1e{-3} \\ \hline 1177 \\ 164(63) \\ \hline \infty \\ \end{array}$	$\begin{array}{c} 1e-5 \\ 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e-5 \\ \hline \\ 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star 4} \\ 1e-5 \\ \hline \\ 335 \\ 2263(2310) \\ \infty \\ \hline \\ 14(29)^{\star 4} \\ 1e-5 \\ \hline \\ 829 \\ \infty \\ \infty \\ 2.5(0.2)^{\star 4} \\ 1e-5 \\ \hline \\ 14(29)^{\star 4} \\ 1e-5 \\ 1e$	$\begin{array}{c} 1e{\text{-}7} \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{*} 4 \\ 1e{\text{-}7} \\ \hline 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{*} 4 \\ 1e{\text{-}7} \\ \hline 1e{\text{-}7} \\ \hline 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{*} 4 \\ 1e{\text{-}7} \\ \hline 1e{\text{-}7} \\ \hline 880 \\ \infty 5e5 \\ \infty 5e5 \\ 2.5(0.2)^{*} 4 \\ 1e{\text{-}7} \\ \hline 1673 \\ 391(177) \\ \infty 5e5 \\ \end{array}$	#succ 15/15 5/15 5/15 1/15 15/15 15/15 15/15 0/15 0/15 0/15 15/15 0/15 15/15 0/15 15/15 15/15 0/15 15/15 15/15 0/15 15/15 15/15 0/15 15/15 0/15 15/15	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC SSEABC ABC SSEABC SSEABC ABC SSEABC ABC SSEABC SSEABC ABC ABC SSEABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} 1 \text{ let} \\ 1 \text{ let} \\ 35(30) \\ 35(23) \\ 34(48) \\ 47(43) \\ 47(43) \\ 47(751) \\ 7.2(3) \\ 6.9(3) \\ 47(751) \\ 7.2(3) \\ 6.9(3) \\ 2.0(2) \\ 4.6(3) \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ let} \\ 1 \text{ let} \\ 1 \text{ let} \\ 1 \text{ let} \\ 2.0(2) \\ 1 \text{ let} \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ let} \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ let} \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ let} \\ 1 \text{ let} \\ 2.6(2) \\ 3.2(2) \\ 1 \text{ let} \\ 3.2(2) \\ 2.6(3) \\ 1 \text{ let} \\ 3.2(3) \\ 1 \text{ let} \\ 3.0 \\ 2.2(3) \\ 1.5(0.8) \\ 1.5(0$	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7)^{\star}2\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 386\\ 326(1296)\\ 18(13)\\ 7.6(13)\\ 40(112)\\ 1e0\\ 518\\ 20(15)\\ 59(71)\\ 100\\ 100\\ 100\\ 100\\ 100\\ 100\\ 100\\ 1$	$\begin{array}{c} 1 e-1 \\ 242 \\ 2450(4336) \\ 700(368) \\ 332c(3344) \\ 158(101)^* \\ 1e-1 \\ \hline \\ 33111 \\ 27(17) \\ 0.55(0.5) \\ 1e-1 \\ 1674 \\ 2c2(523) \\ 6.1(24) \\ 6.7(8) \\ 13(16) \\ 16.1 \\ e-1 \\ \hline \\ 938 \\ 469(534) \\ 337(402) \\ 358(55) \\ 51(51) \\ 1e-1 \\ 14249 \\ 243(189) \\ \infty \end{array}$	$\begin{array}{c} 10-2\\ 1-2\\ \hline 1.0e5\\ 67(85)\\ 68(48)\\ 69(51)\\ 2  3.4(3)^{\pm}2\\ 1e-2\\ 20(22)\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 1692\\ 260(370)\\ 68(232)\\ 10(8)\\ 13(15)\\ 13(15)\\ 11e-2\\ 450(1022)\\ 648(1160)\\ 11\\ 237(384)\\ 60(94)\\ 1e-2\\ 27890\\ \infty\end{array}$	$\begin{array}{c} 1e^3 \\ 1e^3 \\ 1.2e5 \\ 60(105) \\ 60(07) \\ \infty \\ 6.0(3)^{*2} \\ 1e^3 \\ 19(21) \\ 10$	$\begin{array}{c} 1e-5\\ 1.2e5\\ 61(69)\\ \infty\\ \infty\\ \infty\\ 6.0(3)^{\star}2\\ 1e-5\\ 1e-5\\ 1e-5\\ 1e-5\\ 1e-5\\ 13(14)\\ 1e-5\\ 1729\\ 255(506)\\ 13(14)\\ 1e-5\\ 1040\\ 429(726)\\ 6832(1e4)\\ 3312(2932)\\ 81(e8)\\ 1e-5\\ 1e-5\\ 33030\\ \infty\\ \infty\\ \end{array}$	$\begin{array}{c} 1.e-7 \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\star}2 \\ 1e-7 \\ \hline 55313 \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e-7 \\ \hline 1757 \\ 252(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e-7 \\ \hline 1068 \\ 422(704) \\ \infty 5e5 \\ 6897(4331) \\ 93(201) \\ 1e-7 \\ \hline 34256 \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ \end{array}$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           11/15           15/15           11/15           #succ           14/15           8/15           8/15           12/15           #succ           14/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
Af <sub>opt</sub> ry SSEABC GA ABC SSEABC SSEABC ABC SSEABC ABC SSEABC SSEABC SSEABC ABC SSEABC	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 19(30) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 4.7(1) \\ 1e1 \\ \hline 352(12) \\ 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 14(12) \\ 35(1) \\ 14(1416) \\ 2375(3287) \\ 2.1e4(2e4) \\ 3.5(1)^{\pm}4 \\ 1e1 \\ \hline 143 \\ 91(89) \\ 338(1814) \\ 160(289) \\ 160(289) \\ \hline 143 \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(289) \\ 184(160(280) \\ 1$	$\begin{array}{c} 1e0\\ 324\\ 9.5(14)\\ 9.5(14)\\ 35(8)\\ 16(8)\\ 1.9(2)\\ 1e0\\ 273\\ 153(4)\\ 837(2016)\\ 12(13)\\ 5.6(7)\\ 1e0\\ 127\\ 328(1013)\\ 5.6e(5e4)\\ 69(66)\\ 117(12)\\ 83(103)\\ 5.6e(5e4)\\ 69(66)\\ 3259(4409\\ \infty\\ \infty\\ 3.1(0.3)\\ 1e0\\ 202\\ 235(144)\\ 7124(4983)\\ 6082(325)\\ 1e0\\ \infty\\ 3.1(0.3)\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0\\ 1e0$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 1e-1 \\ 0 \\ \infty \\ 0.0(9)^{\star}3 \\ 1e-1 \\ 763 \\ 123(68) \\ 9334(7701) \\ 0 \\ 0 \\ 334(7701) \\ \end{array}$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{*3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(36c2) \\ 14(0.8)^{*3} \\ 1e{-2} \\ 607 \\ \infty \\ 4 \\ 3.0(0.4)^{*4} \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 4 \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ $	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ \infty \\ 1e{-3} \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 626 \\ \infty \\ \infty \\ 1e{-3} \\ 1177 \\ 164(63) \\ \infty \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 1e{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(131) \\ 1e{-5} \\ 410 \\ 781(90) \\ \infty \\ \infty \\ 1e{-5} \\ 335 \\ 2363(2310) \\ \infty \\ \infty \\ 1e{-5} \\ 829 \\ \infty \\ \infty \\ 2.5(0.2) \\ *4 \\ 1e{-5} \\ 14(7) \\ 243(170) \\ \infty \\ $	$\begin{array}{c} 1e-7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 14(1)^{*4} \\ 1e-7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ 565 \\ 565 \\ 14(8)^{*4} \\ 1e-7 \\ 369 \\ 2753(1061) \\ \infty 5e5 \\ 5753(1061) \\ \infty 5e5 \\ 13(17)^{*4} \\ 1e-7 \\ 1e-7 \\ 1e-7 \\ 255 \\ 2.5(0.2)^{*4} \\ 1e-7 \\ 1e-7 \\ 391(177) \\ \infty 5e5 \\ 2.5(0.2)^{*4} \\ 1e-7 \\ 1673 \\ 391(177) \\ \infty 5e5 \\ \infty 5e5 \\ 565 \\ \infty 5e5 \\ 0.5(100) \\ 1673 \\ 391(177) \\ \infty 5e5 \\ \infty 5e5 \\ 0.5(100) \\ 1673 \\ 391(177) \\ \infty 5e5 \\ \infty 5e5 \\ 0.5(100) \\ 1673 \\ 391(177) \\ 0.5(100) \\ 1673 \\ 391(177) \\ 0.5(100) \\ 0.5(100) \\ 1673 \\ 100 \\ 10$	#succ 15/15 5/15 5/15 1/15 15/15 15/15 15/15 0/15 0/15 0/15 0/15 0/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 0/15 15/15 0/15 15/15 0/15 0/15 15/15 0/15 15/15 0/15 15	$\frac{\Delta f_{opt}}{f19}$ PSO GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC	$\begin{array}{c} 1 \text{ set} \\ 1 \text{ let} \\ 1 \\ 35(30) \\ 35(23) \\ 34(43) \\ 1 \text{ let} \\ 1 \\ 47(43) \\ 1 \\ 1 \\ 1 \\ 6 \\ 8.7(4) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \\ 1 \\ 2.0(2) \\ 4.6(3) \\ 2.0(2) \\ 2.1(1) \\ 1 \\ 1 \\ 2.0(2) \\ 2.1(1) \\ 1 \\ 1 \\ 2.0(2) \\ 1 \\ 2.0(2) \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ $	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ \\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7) \star 2\\ 12(15)\\ 1e0\\ \\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ \\ 1.8(2)\\ 5.0(8)\\ 1e0\\ \\ 326(1296)\\ 18(13)\\ 7.6(13)\\ 40(112)\\ 1e0\\ \\ 518\\ 20(15)\\ 559(71)\\ 19(38)\\ 19(10)\\ 10(1$	1e-1           242           2450(4336)           382(4344)           158(101)*           1e-1           383111           27(17)           1.00(0.1)           0.55(0.5)           18(25)           1e-1           1674           262(52)           61(161)           6.7(8)           262(53)           38(46)(534)           38(45)           38(55)           51(51)           1e-1           14249           243(189)           ∞           ∞           ∞           ∞	10-5           1-0-5           67(85)           67(85)           68(48)           2           1-0-2           100-2           100-2           14(31)           1e-2           260(23)           14(31)           1e-2           260(370)           68(232)           10(8)           13(15)           127(384)           60(94)           1e-2           27890           ∞           27(32,*	1e-3 1.2e5 60(105) 60(57) ∞ 6.0(3)*2 1e-3 54470 19(21) 1.3(0.1) 0.58(0.2) 13(25) 1e-3 1705 258(734) 13(13) 16-3 1705 258(734) 13(13) 1008 439(466) 439(466) 1e-3 31654 ∞ ∞ ∞ 20(1)* *	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ $	$\begin{array}{c} 1.e^{-7} \\ 1.2e5 \\ 61(32) \\ \infty 5e5 \\ 5.9(6)^{\pm}2 \\ 1e^{-7} \\ 18(23) \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 252(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e^{-7} \\ 1068 \\ 422(704) \\ \infty 5e5 \\ 6897(4311) \\ 93(201) \\ 1e^{-7} \\ 34256 \\ \infty 5e5 \\ 0.5e5 \\$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           14/15           15/15           1/15           11/15           15/15           1/15           8/15           8/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
Af <sub>opt</sub> <b>f</b> 7 PSO GA ABC SSEABC ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEABC SSEABC GA ABC SSEA	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 15.9(3) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 187(c2) \\ 6.0(1) \\ 187(c2) \\ 6.0(1) \\ 187(c2) \\ 4.7(1) \\ 1e1 \\ \hline 335 \\ 24(11) \\ 418(128) \\ 14(12) \\ 9.0(3) \\ 1e1 \\ \hline 9.0(3) \\ 1e1 \\ \hline 35(1287) \\ 2.1e4(2e4) \\ 3.5(1) \\ 44 \\ 1e1 \\ \hline 143 \\ 91(89) \\ 338(1814) \\ 160(289) \\ 8.5(0.7) \\ \star \end{array}$	$\begin{array}{c} 1e0\\ \hline 324\\ 9.5(14)\\ 9.5(14)\\ 35(8)\\ 16(8)\\ 16(8)\\ 16(8)\\ 135(4)\\ 837(2016)\\ 12(13)\\ 837(2016)\\ 12(13)\\ 5.6(7)\\ 1e0\\ \hline 938(1013)\\ 5.6e4(5e4)\\ 69(66)\\ 11(12)^* 3\\ 11(12)^* 3\\ 11(12)^* 3\\ 1e0\\ \hline 111(12)^* 3\\ 1e0\\ \hline 222\\ 225(144)\\ 7124(4983)\\ 6082(5255)\\ 7.2(0.7)^{*} \end{array}$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628)^{\star}3 \\ 1e-1 \\ 763 \\ 0.0(0.1)^{\star} \\ 1e-1 \\ 1e-1 \\ 763 \\ 0.0(0.1)^{\star} \\ 1e-1 \\ 1e-1 \\ 763 \\ 0.0(0.1)^{\star} \\ 1e-1 \\$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1e{-2} \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{*3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{*3} \\ 1e{-2} \\ 607 \\ \infty \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ \infty \\ 4 \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ \infty \\ 4 \\ 1.8(0.3)^{*4} \end{array}$	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 14(9)^{\star 4} \\ 1e{-3} \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 1e{-3} \\ 1137 \\ 1e{-3} \\ 1137 \\ 164(63) \\ \infty \\ \infty \\ 1.6(0.1)^{\star 4} \\ 1e{-3} \\ 1000 \\ \infty \\ 1.6(0.1)^{\star 4} \\ 1000 \\ 1$	$\begin{array}{c} 1e{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e{-5} \\ 410 \\ 781(90) \\ \infty \\ 14(1.0)^{\star 4} \\ 1e{-5} \\ 335 \\ 2253(2310) \\ \infty \\ 1e{-5} \\ 829 \\ \infty \\ 2.5(0.2)^{\star 4} \\ 1e{-5} \\ 1467 \\ 243(170) \\ \infty \\ 14(0.1)^{\star 4} \end{array}$	$\begin{array}{c} 1e{\text{-}7} \\ 1597 \\ 533(895) \\ 523(1024) \\ 11559(2374) \\ 114(1)^{*}4 \\ 1e{\text{-}7} \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{*}4 \\ 1e{\text{-}7} \\ 369 \\ 2753(1061) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{*}4 \\ 1e{\text{-}7} \\ 880 \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 2.5(0.2)^{*}4 \\ 1e{\text{-}7} \\ 1673 \\ 391(177) \\ \infty 5e5 \\ \infty 5e5 \\ 1.3(0.1)^{*}4 \end{array}$	#succ 15/15 5/15 5/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 0/15 15/15	$\Delta f_{opt}$ f19 PSO GA $\Delta f_{opt}$ f20 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f21 PSO GA $\Delta f_{opt}$ f22 PSO GA $\Delta ABC$ SSEAB(C $\Delta f_{opt}$ f22 PSO GA $\Delta ABC$ SSEAB(C $\Delta f_{opt}$ f22 PSO GA $\Delta ABC$ SSEAB(C $\Delta f_{opt}$ f22 PSO GA $\Delta F_{opt}$ f22 PSO GA $\Delta BC$ SSEAB(C $\Delta F_{opt}$ f22 PSO GA $\Delta BC$ SSEAB(C $\Delta F_{opt}$ f22 PSO GA $\Delta BC$ SSEAB(C $\Delta F_{opt}$ f23 PSO GA $\Delta BC$ SSEAB(C $\Delta F_{opt}$ f23 f23 PSO GA $\Delta BC$ SSEAB(C $\Delta F_{opt}$ f23 PSO GA ABC SSEAB(C $\Delta F_{opt}$ f23 PSO GA ABC SSEAB(C $\Delta F_{opt}$ f23 PSO ABC SSEAB(C $\Delta ABC$ SSEAB(C ABC SS	$\begin{array}{c} 1 \text{ sc}(3) \\ 1 \text{ let} \\ 1 \\ 1 \\ 35(3) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 47(43) \\ 1 \\ 47(51) \\ 7.2(3) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \\ 41 \\ 2.0(2) \\ 4.6(3) \\ 3.2(2) \\ 2.1(1) \\ 1 \\ 1 \\ 1 \\ 1 \\ 2.2(2) \\ 2.6(2) \\ 1.5(0.8) \\ 2.2(2) \\ 2.6(2) \\ 1.5(0.8) \\ 2.2(2) \\ 2.6(2) \\ 1.5(0.8) \\ 2.2(2) \\ 2.6(2) \\ 1.5(0.8) \\ 1.5(0.8) \\ 2.2(2) \\ 2.6(2) \\ 1.5(0.8) $	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(578)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7)^{\star}2\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 1157\\ 326(1296)\\ 18(13)\\ 7.6(13)\\ 40(112)\\ 1e0\\ 518\\ 20(15)\\ 59(71)\\ 19(38)\\ 10(10)\\ \end{array}$	$\begin{array}{c} 1 e-1 \\ 242 \\ 2450(4336) \\ 700(368) \\ 332(344) \\ 1158(101)^{\star} \\ 1e^{-1} \\ 381111 \\ 27(17) \\ 1158(25) \\ 1e^{-1} \\ 1674 \\ 262(523) \\ 18(25) \\ 1e^{-1} \\ 1674 \\ 262(523) \\ 61(161) \\ 6.7(8) \\ 13(16) \\ 16^{-1} \\ 37(402) \\ 33$	1e-2           1.0e5           67(85)           68(48)           69(51)           2           3.4(3)*2           1e-2           1.0(0.2)           0.48(0.5)           14(31)           1e-2           260(370)           68(232)           10(8)           13(15)           1e-2           27(384)           60(94)           1e-2           27890           ∞           ∞           25(33)*	1e-3 1-25 60(105) 60(57) 0 54470 19(21) 1-3(0.1) 0.58(0.2) 13(25) 1e-3 1705 258(734) 70(154) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(14) 13(15) 68(66) 1e-3 31(654) 0 22(21)*	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ \infty \\ \infty \\ 6.0(3)^{\star}2 \\ 1e-5 \\ 13(14) \\ 1e-5 \\ 13(14) \\ 1e-5 \\ 1729 \\ 13(14) \\ 1e-5 \\ 139(219) \\ 84(138) \\ 13(10) \\ 1e-5 \\ 1040 \\ 429(726) \\ 6332(1e4) \\ 3312(2932) \\ 81(88) \\ 1e-5 \\ 33030 \\ \infty \\ \infty \\ \infty \\ \infty \\ 21(14)^{\star} \\ \end{array}$	$\begin{array}{c} 1.e^{-7} \\ 1.e^{-2} \\ 1.2e^{-5} \\ 0.5e^{-5} \\ 0$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           0/15           10/15           11/15           15/15           11/15           15/15           11/15           11/15           8/15           8/15           8/15           8/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
Afopt PSO GA ABC ABC SSEABC AG ABC SSEABC Afopt PSO GA ABC SSEABC Afopt PSO GA ABC SSEABC Afopt PSO GA ABC SSEABC Afopt PSO GA ABC ABC ABC ABC ABC ABC ABC AB	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 13(5) \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 14(2)$	1e0 324 9.5(14) 9.5(14) 16(8) 1.9(2) 1e0 7.73 155(4) 837(2016) 12(13) 5.5.6(7) 1e0 12(13) 5.5.6(7) 10 11(12)*3 1e0 500 3259(4409) 00 3259(4409) 00 3259(4409) 00 325(1409) 00 325(1409) 00 325(255) 10 10 10 10 10 10 10 10 10 10	$\begin{array}{c} 1e-1 \\ \hline 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ \hline 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star 2} \\ 1e-1 \\ \hline 214 \\ 678(631) \\ \infty \\ 699(628) \\ 3.0(0.1)^{\star 1} \\ 1e-1 \\ \hline 763 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1e-1 \\ \hline 763 \\ 123(68) \\ 9351(1e4) \\ 9351(1e4) \\ 9351(1e4) \\ 9351(1e4) \\ 9351(1e4) \\ 1e-1 \\ \hline 763 \\ 123(68) \\ 9351(1e4) \\ 1e-1 \\ \hline 763 \\ 123(68) \\ 9351(1e4) \\ 1e-1 \\ \hline 763 \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(68) \\ 123(710) \\ 123(68) \\ $	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 2245(265) \\ 464(514) \\ 1.4(1)^{*3} \\ 1e{-2} \\ 372 \\ 313(18) \\ 480(875) \\ 14(31)^{*3} \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{*3} \\ 1e{-2} \\ 607 \\ \infty \\ 309(0.4)^{*4} \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ 4 \\ 1e{-2} \\ 4 \\ 1e{-2} \\ 140(2,3)^{*4} \\ 1e{-2} \\ 300(2,3)^{*4} \\ 1e{-2} \\ 3$	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e{-3} \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ \hline \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 1177 \\ 164(63) \\ \infty \\ \infty \\ \infty \\ 1.6(0.1)^{\star 4} \\ 1e{-3} \\ \end{array}$	$\begin{array}{c} 1e{-5} & \\ 1572 & 541(644) \\ 524(415) & \\ 957(1331) & \\ 1e{-5} & \\ 410 & \\ 781(90) & \\ \infty & \\ \infty & \\ \infty & \\ \infty & \\ 14(1.0)^{*}4 & \\ 1e{-5} & \\ 335 & \\ 2363(2310) & \\ \infty & \\ 14(29)^{*}4 & \\ 1e{-5} & \\ 1e{-5} & \\ 829 & \\ \infty & \\ \infty & \\ 2.5(0.2)^{*}4 & \\ 1e{-5} & \\ 1467 & \\ 243(170) & \\ \infty & \\ \infty & \\ \infty & \\ 1.4(0.1)^{*}4 & \\ 1e{-5} & \\ 1467 & \\ 243(170) & \\ \infty & \\ \infty & \\ 1.4(0.1)^{*}4 & \\ 1e{-5} & \\ 1467 $	$\begin{array}{c} 1e\text{-}7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 1.4(1)^{*}4 \\ 1e\text{-}7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17)^{*}4 \\ 1e\text{-}7 \\ 16\text{-}7 \\ 16\text{-}7 \\ 880 \\ \infty 5e5 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ $	#succ 15/15 6/15 1/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 0/15 0/15 0/15 0/15 0/15 0/15 15/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 0/15 15/1	Afopt f19 PSO GA ABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC SSEABC ABC ABC ABC ABC ABC ABC ABC	$\begin{array}{c} 1 \text{ cl} \\ 1 \text{ cl} \\ 1 \text{ cl} \\ 1 \text{ cl} \\ 35(30) \\ 35(23) \\ 35(23) \\ 35(23) \\ 47(43) \\ 1 \text{ cl} \\ 47(43) \\ 1 \text{ cl} \\ 1 \text{ cl} \\ 47(43) \\ 1 \text{ cl} \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ cl} \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ cl} \\ 2.0(2) \\ 4.6(3) \\ 3.2(2) \\ 2.1(1) \\ 1 \text{ cl} \\ 1 \text{ cl} \\ 2.0(2) \\ 1 \text{ cl} \\ 1 \text{ cl} \\ 7.1 \\ 2.2(3) \\ 2.2(3) \\ 1.5(0.8) \\ 2.2(2) \\ 2.2(2) \\ 2.2(2) \\ 2.2(2) \\ 1 \text{ cl} \\ 1 $	$\begin{array}{c} 1e0 \\ 1 \\ 3381(3064) \\ 1.2e4(7520) \\ 2898(1540) \\ 2379(5798) \\ 1e0 \\ 851 \\ 3.1(1.0) \\ 21(6) \\ 1.5(0.7) \star^2 \\ 12(15) \\ 1e0 \\ 1157 \\ 379(541) \\ 5.5(2) \\ 1.8(2) \\ 5.0(8) \\ 1e0 \\ 326(1296) \\ 18(13) \\ 7.6(13) \\ 40(112) \\ 1e0 \\ 518 \\ 20(15) \\ 59(71) \\ 19(38) \\ 10(10) \\ \end{array}$	1e-1           242           2450(436)           326(334)           158(101)*           1e-1           33111           27(17)           16(5)           382(5)           18(25)           18(25)           18(25)           18(25)           18(25)           18(25)           18(25)           18(25)           18(25)           18(25)           18(25)           13(16)           16-1           1674           262(523)           63(161)           6-7(8)           13(16)           11249           243(189)           ∞           6.1(13)*	$\begin{array}{c} 10-2\\ 1-2\\ 10-5\\ 67(85)\\ 69(51)\\ 29(25)\\ 1-2\\ 20(22)\\ 1.0(0.2)\\ 0.48(0.5)\\ 14(31)\\ 1e-2\\ 260(370)\\ 68(232)\\ 10(8)\\ 13(15)\\ 1e-2\\ 39(01022)\\ 648(1160)\\ 1237(384)\\ 60(94)\\ 1e-2\\ 277(384)\\ 60(94)\\ 1e-2\\ 277(384)\\ 60(94)\\ 1e-2\\ 27890\\ \infty\\ \infty\\ 25(33)^{\star} \end{array}$	$\begin{array}{c} 1e^{-3} \\ 1e^{-3} \\ 1.2e5 \\ 60(15) \\ 60(5) \\ \infty \\ e^{-3} \\ 19(21) \\ 1.3(0.1) \\ 0.58(0.2) \\ 13(25) \\ 1e^{-3} \\ 13(25) \\ 1e^{-3} \\ 13(13) \\ 13(14) \\ 14(14) \\ 14($	$\begin{array}{c} 1.2 + 5 \\$	$\begin{array}{c} 1.e^{-7} \\ 1.2e^{-5} \\ 61(32) \\ \infty 5e^{-5} \\ 5.9(6)^{\pm} 2 \\ 1e^{-7} \\ 5.0(7) \\ 2.6(2) \\ 13(14) \\ 1e^{-7} \\ 1757 \\ 25(214) \\ 291(292) \\ 265(149) \\ 15(22) \\ 1e^{-7} \\ 1068 \\ 422(704) \\ \infty 5e^{-5} \\ 6897(4311) \\ 93(201) \\ 1e^{-7} \\ 34256 \\ \infty 5e^{-5} \\ \infty 5e^{-5} \\ 21(16)^{\pm} \\ e^{-3} \\ 1e^{-5} \\ 1e^{-7} \\ 137 \\ 1068 \\ 1e^{-7} \\ 1068 \\ 1e^{-7} \\ 1068 \\ 1e^{-7} \\ 1168 \\ 1e^{-7} \\ 1068 \\ 1e^{-7} \\ 1e^{-7$	#succ           15/15           0/15           0/15           0/15           0/15           14/15           15/15           15/15           15/15           15/15           14/15           8/15           8/15           14/15           8/15           11/15           11/15           11/15           11/15           11/15           11/15           11/15           11/15           11/15           11/15
A	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 5.9(3) \\ 1e1 \\ 13(5) \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 4.7(1) \\ 1e1 \\ 35 \\ 24(11) \\ 14(12) \\ 9.0(3) \\ 141(12) \\ 9.0(3) \\ 141(16) \\ 237(3287) \\ 141(16) \\ 237(3287) \\ 161 \\ 143 \\ 1533(1814) \\ 160(289) \\ 8.5(0.7)^{\star} \\ 1e1 \\ 1e1 \\ 10 \\ 10 \\ 8.5(0.7)^{\star} \end{array}$	$\begin{array}{c} 1 e0 \\ \hline 324 \\ 9.5(14) \\ 9.5(14) \\ 160 \\ \hline 273 \\ 153(4) \\ 153(4) \\ 153(4) \\ 153(2016) \\ 12(13) \\ 5.6(75016) \\ 12(13) \\ 5.6(4504) \\ 12(13) \\ 5.6(4504) \\ 100 \\ \hline 100 \\ \hline 3259(4409) \\ \infty \\ \infty \\ 3.11(0.3) \\ 1e0 \\ \hline 202 \\ 235(144) \\ 7.124(4983) \\ 102(255) \\ 7.2(0.7)^{*} \\ 1e0 \\ \hline \end{array}$	$\begin{array}{c} 1e-1 \\ \hline 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star 3} \\ 1e-1 \\ \hline 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star 2} \\ 1e-1 \\ \hline 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star 3} \\ 1e-1 \\ \hline \\ 0 \\ \infty \\ \infty \\ \infty \\ \times 4 \\ 3.0(0.1)^{\star} \\ 1e-1 \\ \hline \\ 123(68) \\ 9351(1e4) \\ 9334(7701) \\ 4 \\ 2.1(0.2)^{\star 1} \\ 1e-1 \\ \hline \\ 334(7701) \\ 4 \\ 2.1(0.2)^{\star 1} \\ 1e-1 \\ \hline \\ 3371 \\ 1e-1 \\ \hline \\ 371 $	$\begin{array}{c} 1e-2 \\ \hline 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1.4(1)^{*3} \\ 1e-2 \\ \hline 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{*3} \\ 1e-2 \\ \hline 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{*3} \\ 1e-2 \\ \hline 4000 \\ 0 \\ \infty \\ 4 \\ 3.0(0.4)^{*4} \\ 1e-2 \\ \hline 977 \\ 140(37) \\ \infty \\ 4 \\ 1.8(0.3)^{*4} \\ 1e-2 \\ \hline 977 \\ 140(37) \\ \infty \\ 4 \\ 1.8(0.3)^{*4} \\ 1e-2 \\ \hline 977 \\ 140(37) \\ \infty \\ 4 \\ 1.8(0.3)^{*4} \\ 1.8(0.3)$	$\begin{array}{c} 1e-3 \\ \hline 1572 \\ 541(513) \\ 522(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e-3 \\ \hline \infty \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e-3 \\ \hline \infty \\ 15(0.7)^{\star 4} \\ 1e-3 \\ \hline 626 \\ \hline \infty \\ 4 \\ 1e-3 \\ \hline 626 \\ \hline \infty \\ 4 \\ 1e-3 \\ \hline 626 \\ \hline \infty \\ 4 \\ 1e-3 \\ \hline 626 \\ \hline \infty \\ 626 \\ \hline \infty \\ 16-3 \\ \hline 626 \\ \hline 0 \\ 16-3 \\ \hline 160(1)^{\star 4} \\ 1e-3 \\ 1e-3 \\ \hline 160(1)^{\star 4} \\ 1e-3 \\$	$\begin{array}{c} 1e-5 \\ 1572 \\ 541(644) \\ 522(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e-5 \\ \hline \\ 410 \\ 781(90) \\ \infty \\ \infty \\ 14(1.0)^{\star 4} \\ 1e-5 \\ \hline \\ 335 \\ 2363(2310) \\ \infty \\ \infty \\ 14(29)^{\star 4} \\ 1e-5 \\ \hline \\ 829 \\ \infty \\ \infty \\ 2.5(0.2)^{\star 4} \\ 1e-5 \\ \hline \\ 1467 \\ \infty \\ \infty \\ \infty \\ 14(0.1)^{\star 4} \\ 1e-5 \\ \hline \\ 1467 \\ 243(170) \\ \infty \\ \infty \\ 1467 \\ 1e-5 \\ \hline \\ 1467 \\ 1467 \\ 1e-5 \\ \hline \\ 1467 \\ 1$	$\begin{array}{c} 1e-7 \\ 1597 \\ 533(895) \\ 523(895) \\ 523(1024) \\ 11559(2374) \\ 1.4(1)^{*}4 \\ 1e-7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{*}4 \\ 1e-7 \\ 1e-7 \\ 1e-7 \\ 880 \\ \infty 5e5 \\ \infty 5e5 \\ 2.5(0.2)^{*}4 \\ 1e-7 \\ 1e-7 \\ 1e-7 \\ 1673 \\ 391(177) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 1.3(0.1)^{*}4 \\ 1e-7 \\ 1e-7 \\ 1494 \\ 1e-7 \\ 1e-7 \\ 1494 \\ 1e-7 \\ $	#succ 15/15 6/15 1/15 1/15 1/15 15/15/	$\begin{array}{c} \Delta f_{opt}\\ \overline{f19}\\ PSO\\ GA\\ ABC\\ SSEAB(C\\ \Delta f_{opt}\\ \overline{f20}\\ PSO\\ GG\\ ABC\\ SSEAB(C\\ \Delta f_{opt}\\ \overline{f21}\\ PSO\\ GA\\ ABC\\ SSEAB(C\\ \Delta f_{opt}\\ \overline{f23}\\ PSO\\ GA\\ ABC\\ SSEAB(C\\ \Delta f_{opt}\\ \overline{f24}\\ PSO\\ GA\\ ABC\\ SSEAB(C\\ \Delta f_{opt}\\ \overline{f24}\\ PSO\\ FRO\\ GA\\ ABC\\ SSEAB(C\\ \Delta f_{opt}\\ \overline{f24}\\ PSO\\ FRO\\ FRO\\ FRO\\ FRO\\ FRO\\ FRO\\ FRO\\ FR$	$\begin{array}{c} 1 \text{ sc}(3) \\ 1 \text{ sc}(3) \\ 35(23) \\ 35(23) \\ 35(23) \\ 35(23) \\ 34(48) \\ 47(43) \\ 47(43) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ sc} \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ sc} \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ sc} \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \text{ sc} \\ 47(51) \\ 7.2(3) \\ 1 \text{ sc} \\ 47(51) \\ 7.2(3) \\ 1 \text{ sc} \\ $	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7)^{\star 2}\\ 12(15)\\ 12($	$\begin{array}{c} 1-(y) \\ 1-(z) \\ 242 \\ 2450(4336) \\ 700(366) \\ 3322(3344) \\ 158(101)^{\star} \\ 1e-1 \\ 331111 \\ 27(17) \\ 1.00(0.1) \\ 0.55(0.5) \\ 18(25) \\ 1e-1 \\ 1674 \\ 262(523) \\ 6.1(61) \\ 1674 \\ 262(523) \\ 6.1(61) \\ 1622 \\ 243(189) \\ \infty \\ 6.1(13)^{\star} \\ 1622 \\ \end{array}$	$\begin{array}{c} 1.0 < 5 \\ 1.0 < 5 \\ 6.7 (85) \\ 6.8 (48) \\ 6.9 (51) \\ 2 \\ 3.4 (3) ^{+} 2 \\ 1 \\ -2 \\ 20 (22) \\ 1.0 (0.2) \\ 0.48 (0.5) \\ 14 (31) \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 1 \\ -2 \\ 2 \\ -2 \\ -$	$\begin{array}{c} 1e^3 \\ 1e^3 \\ 1.2e5 \\ 60(105) \\ 600(7) \\ \infty \\ 6.0(3)^{*2} \\ 1e^3 \\ \hline 19(21) \\ 0.58(0.2) \\ 13(25) \\ 1e^3 \\ \hline 19(21) \\ 13(25) \\ 1e^3 \\ \hline 1008 \\ 13(13) \\ 13(14) \\ 14(14) \\$	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ 6.0(3)^{\pm}2 \\ 1e-5 \\ 54861 \\ 19(11) \\ 2.6(0.3) \\ 1.5(2) \\ 13(14) \\ 1e-5 \\ 139(219) \\ 84(138) \\ 1e-5 \\ 134(138) \\ 1e-5 \\ 1040 \\ 429(726) \\ 6832(1e4) \\ 3312(2932) \\ 881(88) \\ 1e-5 \\ 33030 \\ \infty \\ \infty \\ \infty \\ 21(14)^{\pm} \\ 0 \\ 1e-1 \\ 1e-2 \\ 1 \\ 1e-2 \\ 1040 \\ 1e-5 \\ 1$	$\begin{array}{cccc} 1e-7 & & & & \\ 1e-7 & & & & & \\ 1e-3 & & & & & \\ 5.9(6)^{\pm}2 & & & & \\ 1e-7 & & & & \\ 5.9(6)^{\pm}2 & & & \\ 18(23) & & & & \\ 5.0(7) & & & & \\ 2.6(2) & & & & \\ 13(14) & & & \\ 1e-7 & & & & \\ 16-7 & & & & \\ 1757 & & & & \\ 22(214) & & & \\ 291(292) & & & \\ 265(149) & & & \\ 15(22) & & & \\ 1e-7 & & & & \\ 1068 & & & & \\ 22(704) & & & & \\ \infty & 5e5 & & \\ 6897(4331) & & & \\ 93(201) & & & \\ 1e-7 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(22) & & & \\ 167 & & & & \\ 15(23) & & & \\ 167 & & & & \\ 15(23) & & & \\ 167 & & & & \\ 15(23) & & & \\ 167 & $	#succ           15/15           0/15           0/15           0/15           0/15           0/15           0/15           11/15           15/15           15/15           15/15           11/15           #succ           14/15           8/15           8/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           1/15
$\frac{\Delta f_{opt}}{F7}$ PSO GA ABC SSEABC MAC SSEABC ABC ABC SSEABC SSEABC SSSEABC SSEABC SS	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 15.9(3) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 13(5) \\ 14(12) \\ 141(2128) \\ 14(12) \\ 141(2128) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(218) \\ 14(12) \\ 141(116) \\ 123(12) \\ 123(12) \\ 123(12) \\ 123(12) \\ 123(12) \\ 133(12) \\ $	$\begin{array}{c} 1 e0 \\ 324 \\ 9.5(14) \\ 9.5(14) \\ 35(8) \\ 16(8) \\ 1.9(2) \\ 1e0 \\ 273 \\ 153(4) \\ 837(2016) \\ 12(13) \\ 5.6(7) \\ 1e0 \\ 127 \\ 938(1013) \\ 5.6(5c4) \\ 69(66) \\ 11(12)^* \\ 3259(409) \\ \infty \\ 3259(409) \\ \infty \\ 31(0.3) \\ 1e0 \\ 0082(525) \\ 7.2(0.7)^{*1} \\ 1e0 \\ 1$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(10)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 1e-1 \\ 763 \\ 123(68) \\ 9351(1e4) \\ 9334(7701) \\ 4 \\ 2.1(0.2)^{\star} \\ 1e-1 \\ 5406(6065) \\ 1.9e(41e4) \\ 371 \\ 5406(6065) \\ 1.9e(41e4) \\ 1.9e(41e$	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{+}3 \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{+}3 \\ 1e{-2} \\ 607 \\ \infty \\ 4 \\ 3.0(0.4)^{+}4 \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ 4 \\ 1.8(0.3)^{+}4 \\ 1.8(0.3)^{+}4 \\ 1e{-2} \\ 413 \\ 7886(1e4) \\ \infty \end{array}$	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 2510(1785) \\ 14(9)^{\star 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ 15(0.7)^{\star 4} \\ 1e{-3} \\ 164(63) \\ \infty \\ 1.6(0.1)^{\star 4} \\ 1e{-3} \\ 1.64(63) \\ \infty \\ 1.6(0.1)^{\star 4} \\ 1e{-3} \\ 1.5e4(2e4) \\ \infty \end{array}$	$\begin{array}{c} 1e{-5} \\ 1572 \\ 541(644) \\ 524(415) \\ 957(1331) \\ 1.4(0.8)^{\star 4} \\ 1e{-5} \\ 410 \\ \infty \\ 14(1.0)^{\star 4} \\ 1e{-5} \\ 335 \\ 2253(2210) \\ \infty \\ 14(29)^{\star 4} \\ 1e{-5} \\ 829 \\ \infty \\ 2.5(0.2)^{\star 4} \\ 1e{-5} \\ 1467 \\ 243(170) \\ \infty \\ \infty \\ 1.4(0.1)^{\star 4} \\ 1e{-5} \\ 1303 \\ \infty \\ \infty \end{array}$	$\begin{array}{c} 1e-7 \\ 1597 \\ 533(895) \\ 523(1024) \\ 1359(2374) \\ 14(1)^{*4} \\ 1e-7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 14(8)^{*4} \\ 1e-7 \\ 369 \\ 2753(1061) \\ \infty 5e5 \\ 13(17)^{*4} \\ 1e-7 \\ 1e-7 \\ 1e-7 \\ \infty 5e5 \\ \infty 5e5 \\ 2.5(0.2)^{*4} \\ 1e-7 \\ 1e-7 \\ 167 \\ 391(177) \\ \infty 5e5 \\ 2.5(0.2)^{*4} \\ 1e-7 \\ 167 \\ 167 \\ 391(177) \\ \infty 5e5 \\ 1.3(0.1)^{*4} \\ 1e-7 \\ 1494 \\ \infty 5e5 \\ 5e5 \\ 1494 \\ \infty 5e5 \\ 1494 \\ 058 \\ 1494$	#succ 15/15 5/15 1/15 15/15 0/15 15/1	$\begin{array}{c} \Delta f_{opt}\\ \overline{f19}\\ F19\\ FS0\\ GA\\ ABC\\ SSEABC\\ \overline{f20}\\ F20\\ FS0\\ GA\\ ABC\\ SSEABC\\ \overline{f22}\\ FS0\\ GA\\ ABC\\ SSEABC\\ \overline{f23}\\ FS0\\ GA\\ ABC\\ SSEABC\\ \overline{f23}\\ FS0\\ GA\\ ABC\\ SSEABC\\ \overline{f23}\\ FS0\\ \overline{f24}\\ FS0\\ FS0\\ FS0\\ FS0\\ FS0\\ FS0\\ FS0\\ FS0$	$\begin{array}{c} 1 \text{ set} \\ 1 \text{ let} \\ 1 \\ 35(30) \\ 35(23) \\ 34(43) \\ 1 \text{ let} \\ 1 \\ 1 \\ 47(43) \\ 1 \\ 1 \\ 1 \\ 6 \\ 8.7(4) \\ 47(51) \\ 7.2(3) \\ 6.9(3) \\ 1 \\ 1 \\ 47(51) \\ 7.2(3) \\ 2.0(2) \\ 2.0(2) \\ 2.0(2) \\ 2.0(2) \\ 2.0(2) \\ 2.1(1) \\ 1 \\ 1 \\ 1 \\ 1 \\ 2.0(2) \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ $	$\begin{array}{c} 1e0\\ 1\\ 3381(3064)\\ 1.2e4(7520)\\ 2898(1540)\\ 2379(5798)\\ 1e0\\ 851\\ 3.1(1.0)\\ 21(6)\\ 1.5(0.7) \star 2\\ 12(15)\\ 1e0\\ 1157\\ 379(541)\\ 5.5(2)\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 1.8(2)\\ 5.0(8)\\ 1e0\\ 386\\ 326(1296)\\ 18(13)\\ 7.6(13)\\ 40(112)\\ 1e0\\ 518\\ 20(15)\\ 559(71)\\ 19(38)\\ 10(10)\\ \end{array}$	1e-1           242           2450(4336)           382(4344)           158(101)*           162           18(25)           1e-1           18(25)           1e-1           18(25)           1e-1           1674           262(52)           61(161)           6.7(8)           38(46)(534)           38(53)           51(51)           1e-1           14249           243(189)           ∞           ∞           6.1(13)*	1e-2       1.0e5       67(85)       68(48)       2       3.4(3)*2       1e-2       20(22)       1.0(0.2)       0.48(0.5)       14(31)       1e-2       260(370)       68(232)       10(8)       13(15)       1e-2       980       450(1022)       648(1160)       1e-2       27(384)       60(94)       1e-2       27(890)       ∞       ∞       25(33)*	1e-3 1.2e5 60(105) 60(57) ∞ 6.0(3)*2 1e-3 19(21) 1.3(0.1) 0.58(0.2) 13(25) 1e-3 17075 13(25) 1e-3 17075 13(25) 1e-3 1008 439(496) 439(496) 1e-3 1008 1e-3 1008 1008 100	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ $	$\begin{array}{c} 1 e - 7 \\ 1 e - 7 \\ 1 - 2 e - 5 \\ 1 e - 7 \\ 2 e - 6 (2) \\ 1 e - 7 \\ 1$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           0/15           14/15           5/15           15/15           15/15           1/15           #succ           14/15           8/15           8/15           8/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15
$\frac{\Delta f_{opt}}{fr}$ PSO GA ABC SSEABC MABC SSEABC GA ABC SSEABC GA ABC SSEABC ABC SSEABC ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC SSEABC GA ABC	$\begin{array}{c} 1e1 \\ 24 \\ 11(15) \\ 49(47) \\ 19(30) \\ 15.9(3) \\ 1e1 \\ \hline 73 \\ 13(5) \\ 13(5) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 6.0(1) \\ 187(62) \\ 4.7(1) \\ 1e1 \\ \hline 35 \\ 24(11) \\ 1418(128) \\ 14(12) \\ 24(12) \\ 1418(128) \\ 14(12) \\ 1418(128) \\ 141(12) \\ 235(3287) \\ 2.1e4(2e4) \\ 3.5(1)^{\star}4 \\ 1e1 \\ \hline 108 \\ 748(3477) \\ 93(2397) \\ 99(133) \\ 99(133) \\ 108 \\ 748(3477) \\ 93(2397) \\ 99(133) \\ 108 \\ 748(3477) \\ 93(2397) \\ 99(133) \\ 108 \\ 748(3477) \\ 93(2397) \\ 99(133) \\ 108 \\ 748(3477) \\ 93(2397) \\ 99(133) \\ 108 $	$\begin{array}{c} 1 e0 \\ 324 \\ 9.5(14) \\ 9.5(14) \\ 35(8) \\ 16(8) \\ 1.9(2) \\ 1e0 \\ \hline 273 \\ 153(4) \\ 837(2016) \\ 12(13) \\ 5.6(7) \\ 1e0 \\ \hline 127 \\ 335(1013) \\ 5.6e4(5e4) \\ 69(66) \\ 11(12)^* \\ 3325(440) \\ 11(12)^* \\ 3225(440) \\ \hline 11(12)^* \\ 3225(440) \\ 7124(4983) \\ 6082(2525) \\ 7.2(0.7)^{*1} \\ 1e0 \\ \hline 286 \\ 3747(7929) \\ 2447(4671) \\ 547(878) \\ 547(878) \\ \hline \end{array}$	$\begin{array}{c} 1e-1 \\ 1171 \\ 587(953) \\ 57(218) \\ 62(51) \\ 1.4(0.6)^{\star}3 \\ 1e-1 \\ 336 \\ 201(54) \\ \infty \\ 52(120) \\ 8.7(1.0)^{\star}2 \\ 1e-1 \\ 214 \\ 678(631) \\ \infty \\ 699(628) \\ 9.0(9)^{\star}3 \\ 9.0(9)^{\star}3 \\ 9.0(9)^{\star}3 \\ 1e-1 \\ 763 \\ 763 \\ 123(68) \\ 933(7701) \\ 4 \\ 2.1(0.2)^{\star} \\ 1e-1 \\ 763 \\ 763 \\ 9331(1e4) \\ 9334(7701) \\ 4 \\ 2.1(0.2)^{\star} \\ 1e-1 \\ 371 \\ 5406(6065) \\ 1.9.e(1e4) \\ 5846(4067) \\ 1.9.e(1e4) \\ 5846(4067) \\ 1.9.e(1e4) \\ 5846(4067) \\ 1.9.e(1e4) \\ 1.9.e($	$\begin{array}{c} 1e{-2} \\ 1451 \\ 475(487) \\ 245(265) \\ 464(514) \\ 1e{-2} \\ 372 \\ 313(18) \\ \infty \\ 449(875) \\ 14(51)^{+}3 \\ 1e{-2} \\ 263 \\ 794(1464) \\ \infty \\ 3994(3662) \\ 14(0.8)^{+}3 \\ 1e{-2} \\ 607 \\ \infty \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ \infty \\ 4 \\ 3.0(0.4)^{+}6 \\ 1e{-2} \\ 977 \\ 140(37) \\ \infty \\ 4 \\ 1e{-2} \\ 140(.8)^{+}4 \\ 1e{-2} \\ 140(.8)^{+}4 \\ 1e{-2} \\ 413 \\ 7886(1e4) \\ \infty \\ \infty \\ \infty \\ \end{array}$	$\begin{array}{c} 1e{-3} \\ 1572 \\ 541(513) \\ 524(648) \\ 957(1649) \\ 1.4(0.6)^{\star 4} \\ 1e{-3} \\ 391 \\ 467(364) \\ \infty \\ 14(9)^{\star 4} \\ 1e{-3} \\ 300 \\ 1131(1699) \\ \infty \\ 1e{-3} \\ 626 \\ \infty \\ 1e{-3} \\ 1177 \\ 164(63) \\ \infty \\ \infty \\ 1e{-3} \\ 1177 \\ 164(63) \\ \infty \\ \infty \\ 1.5e4(2e4) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ 1.5e4(2e4) \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ \infty \\ 0 \\ \infty \\ \infty \\ \infty$	$\begin{array}{c} 1e{-5} & \\ 1572 & 541(644) \\ 524(415) & \\ 957(1331) & \\ 1e{-5} & \\ 410 & \\ \infty & \\ 1e{-5} & \\ 14(1.0)^{*4} & \\ 1e{-5} & \\ 335 & \\ 2363(2310) & \\ \infty & \\ 1e{-5} & \\ 829 & \\ \infty & \\ 2.5(0.2)^{*4} & \\ 1e{-5} & \\ 1467 & \\ 243(170) & \\ \infty & \\ \infty & \\ 1.4(0.1)^{*4} & \\ 1e{-5} & \\ 1467 & \\ 1467 & \\ 243(170) & \\ \infty & \\ \infty & \\ 1.4(0.1)^{*4} & \\ 1e{-5} & \\ 1303 & \\ \infty & \\ \infty & \\ \end{array}$	$\begin{array}{c} 1e-7 \\ 1597 \\ 533(895) \\ 523(895) \\ 523(1024) \\ 1159(2374) \\ 1e-7 \\ 422 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 1104(98) \\ \infty 5e5 \\ \infty 5e5 \\ 13(17) *4 \\ 1e-7 \\ 1e-7 \\ 1e-7 \\ 880 \\ \infty 5e5 \\ 2.5(0.2) *4 \\ 1e-7 \\ 1e-7 \\ 1673 \\ 391(177) \\ \infty 5e5 \\ 2.5(0.2) *4 \\ 1e-7 \\ 1e-7 \\ 11073 \\ 391(177) \\ \infty 5e5 \\ 1.3(0.1) *4 \\ 1e-7 \\ 1e-7 \\ 1494 \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ \infty 5e5 \\ 0.5e5 \\ 0.5e5$	#succ 15/15 5/15 1/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 15/15 0/15 0/15 0/15 0/15 15/15 15/15 0/15	$\begin{array}{c} \Delta f_{opt}\\ \overline{f19}\\ F19\\ FS0\\ GA\\ ABC\\ SSEABC\\ \Delta f_{opt}\\ \overline{f20}\\ F20\\ GA\\ ABC\\ SSEABC\\ GA\\ ABC\\ SSEABC\\ GA\\ ABC\\ SSEABC\\ \overline{f21}\\ F20\\ FS0\\ GA\\ ABC\\ SSEABC\\ \overline{f22}\\ FS0\\ GA\\ ABC\\ SSEABC\\ SSEAB$	$\begin{array}{c} 1 \text{ set} \\ 1 \text{ let} \\ 1 \\ 3 \text{ 5}(30) \\ 3 \text{ 5}(23) \\ 3 \text{ 5}(23) \\ 3 \text{ 5}(23) \\ 3 \text{ 5}(23) \\ 4 \text{ 7}(43) \\ 1 \text{ set} \\ 1 \text{ set} \\ 4 \text{ 7}(43) \\ 1 \text{ set} \\ 2 \text{ set} \\ 3  $	1e0 1 3381(3064) 1.2e4(7520) 2898(1540) 2379(578) 1e0 851 3.1(1.0) 21(6) 1.5(0.7) *2 12(15) 1e0 1157 379(541) 5.5(2) 1.8(2) 5.0(8) 1e0 336 326(1296) 18(13) 7.6(13) 40(112) 1e0 518 20(15) 59(71) 19(38) 10(10)	1e-1           242           2450(4336)           382(63344)           158(101)*           16-1           383111           27(17)           1158(25)           1e-1           1674           262(523)           61(161)           6.7(8)           262(523)           61(161)           6.7(8)           335(55)           51(51)           1e-1           1622	1e-2       1.0e5       67(85)       2     3.4(3) *2       1e-2       1.0(0.2)       0.48(0.5)       14(31)       1e-2       260(370)       668(232)       10(8)       13(15)       1e-2       237(384)       60(94)       1e-2       27(384)       60(94)       1e-2       27(384)       60(94)       1e-2       27(384)	1e-3 1.2e5 60(105) 60(57) ∞ 6.0(3)*2 1e-3 54470 19(21) 1.3(0.1) 0.58(0.2) 13(25) 1e-3 1705 258(734) 13(13) 13(13) 13(13) 13(13) 13(13) 13(13) 13(13) 13(13) 13(14) 13(13) 13(13) 13(14) 13(13) 16-3 13(14) 13(14) 13(13) 16-3 1005 439(173) 31(54) ∞ ∞ ∞ 22(21)* 12 22 22 22 22 22 22 22 22 22	$\begin{array}{c} 1e-5 \\ 1.2e5 \\ 61(69) \\ \infty \\ \infty \\ \infty \\ 6.0(3)^{\pm}2 \\ 1e-5 \\ 13(14) \\ 1e-5 \\ 13(14) \\ 1e-5 \\ 13(219) \\ 84(138) \\ 13(10) \\ 1e-5 \\ 10(14) \\ 10($	$\begin{array}{c} 1.e^{-7} \\ 1.e^{-2} \\ 1.2e^{-5} \\ 0.5e^{-5} \\ 0$	#succ           15/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           11/15           15/15           11/15           #succ           14/15           8/15           12/15           #succ           14/15           8/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15           0/15

Table 2: Average runtime (aRT in number of function evaluations) divided by the respective best aRT measured during BBOB-2009 in dimension 5. The aRT and in braces, as dispersion measure, the half difference between 10 and 90%-tile of bootstrapped run lengths appear for each algorithm and target, the corresponding reference aRT in the first row. The different target  $\Delta f$ -values are shown in the top row. #succ is the number of trials that reached the (final) target  $f_{opt} + 10^{-8}$ . The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries, succeeded by a star, are statistically significantly better (according to the rank-sum test) when compared to all other algorithms of the table, with p = 0.05 or  $p = 10^{-k}$  when the number k following the star is larger than 1, with Bonferroni correction of 110. A  $\downarrow$  indicates the same tested against the best algorithm from BBOB 2009. Best results are printed in bold. Data produced with COCO v2.1

#### GECCO '17 Companion, July 15-19, 2017, Berlin, Germany

Dogan Aydin et. al.

$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1		1e0	1e-1	1e	-2	1e-3		1e-5	1e-7	#succ
f1	43	43	43	43	43	43	43	15/15	f13	652		2021	27	51	3507	1	8749	24455	30201	15/15
GA	22(8) 876(70)	3399(1e4) 1905(150)	3446(30) 3205(297)	3507(20) 1 2e4(1e4)	3563(31) 3 1e4(4e4)	3680(1e4) 6 7e5(7e5)	3808(1e4)	14/15	GA	6153(1e4) 5114(7690)		6441(9154)	1.0e4(65	43) 799	3(8982)	1495(20	00)	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	∞ 2e6	0/15
ABC	36(20)	66(39)	94(44)	136(51)	177(58)	292(21)	374(29)	15/15	ABC	25(12)		73(78)	627(764)	393	1(4428)	1555(18	40)	~	∞ 2e6	5 0/15
SSEABC	9.4(0.8) <sup>*3</sup>	<b>16</b> (1) <sup>*4</sup>	22(2) <sup>*4</sup>	28(2) <sup>*4</sup>	34(1) <sup>*4</sup>	48(2) <sup>*4</sup>	<b>61</b> (3) <sup>*4</sup>	15/15	SSEABC	4.0(3)*3	3	<b>5.6</b> (9) <sup>*3</sup>	22(19)*	3 3	1(47) <sup>*3</sup>	<b>15</b> (21	) <sup>*2</sup>	$\infty$	∞ 2e5	0/15
$\Delta f_{\text{opt}}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{\text{opt}}$	1e1	1e0	)	1e-1	1e-2	1e-3	1	e-5	1e-7		#succ
f2	385	386	387	388	390	391	393	15/15	f14	75		239	304	451	93	2	1648	1	5661	15/15
PSO GA	4576(6494) 3228(7787)	4571(7774)	4565(3877) 7 3e4(8e4)	4560(5152)	4543(1e4)	4546(8955)	4537(6364)	8/15	PSO GA	6.7(3)	12	(3)	20(3)	27(5) 2808(3457)	54(16)	0	0	$\infty 2$ $\infty 2$	'e6 'e6	0/15
ABC	12(3)*4	16(3)*4	23(4)*4	30(6)*4	40(8)*3	56(5)*4	70(4)*4	15/15	ABC	18(9)	18	(11)	28(12)	53(7)	3379(240	9) o	0	∞ 2 ∞ 2	e6	0/15
SSEABC	37(6)	44(4)	52(3)	101(67)	242(128)	1031(1407)	∞ 2e5	0/15	SSEABC	5.2(1)	3	.2(0.4)*4	4.0(0.3)*4	4.5(0.5)*	4 4.3(0	.5) <sup>*4</sup> 6.	4(0.7) <sup>*4</sup>	3.8(2	)*4	0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1						1e0 1e-1	1e-2 1e	-3 1e-5	1e-7	#succ
f3	5066	7626	7635	7637	7643	7646	7651	15/15	f15				30378			1.5e5 3.1e5	3.2e5 3.2	e5 4.5e5	4.6e5	15/15
PSO	∞ ≈	∞ 2500(0054)	~	~	~	~	∞ 2e6	0/15	PSO	~						∞ ∞	~ ~	~ ~~	∞ 2e6	0/15
GA	29(2)	3709(3871)	∞ ≂ = (=) *4	∞ 	∞ 	∞ 	∞ 2e6	0/15	GA	~						~ ~	$\infty \propto \infty$	$\sim \infty$	$\infty 2ec$	0/15
SSEABC	28(17)	2.7(1) ∞	3.0(2) ∞	3.2(2) ∞	3.6(1) ∞	4.1(0.8) ∞	4.9(0.5) ∞ 2e5	0/15	SSEABC	<b>0.61</b> (0.0)*4	ł					∞ ∞	~ ~	, <u>~</u>	∞ 2e5	5 0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1		1e0	)	1	e-1		1e-2 1e	-3 1e-5	1e-7	#succ
f4	4722	7628	7666	7686	7700	7758	1.4e5	9/15	f16		1384		27265		7701	5	1.4e5 1.9	e5 2.0e5	2.2e5	15/15
PSO	5940(9530)	~	$\infty$	$\infty$	$\infty$	$\infty$	∞ 2e6	0/15	PSO	111(364)		~		c	×		$\infty \propto$	~ ~~	∞ 2e6	0/15
GA	65(3)	3751(4657)	∞ ★4	∞ +4	∞ ★4	∞ +4	∞ 2e6 +4	0/15	GA	138(24)		103	7(1853)	-	xo vo		~ ~	~~~~	∞ 2e6	0/15
ABC	2.0(1)	4.2(1) ***	5.6(3)	6.0(1) <sup></sup>	6.3(1)	7.3(5)	0.45(0.3)	15/15	SEARC	13(12)		~	<b>0 40</b> (0 0)*4	4	$\sim \alpha(0) \star 4$		~ ~	~~~~	∞ 2et	0/15
A.C.		1-0	1-1	1- 2	1- 2	1-5	1-7	u	A.F.	1.3(1)	1-(	0	1- 1	1-0	.9(5)		1-5	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1- 7	1
Jopt	41	100	1e-1 41	1e-2 41	10-5	1e-5	10-7	#succ 15/15	Jopt f17	1e1 63	100	1030	10-1	1e-2	242	30677	1e-5 56'	288	80472	#succ
PSO	4.3e4(5e4)	4.3e4(4e4)	4.3e4(9e4)	4.3e4(7e4)	4.3e4(7e4)	4.3e4(7e4)	4.3e4(6e4)	8/15	PSO	3.2(2)	250	)3(1944)	~	~ ~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	50077	~	200	∞ 2e6	5 0/15
GA	2137(191)	4548(244)	7446(322)	1.1e4(482)	1.4e4(491)	2.2e4(780)	2.3e5(3e5)	0/15	GA	57(60)	9	92(7)	7071(8495)	$\infty$	$\infty$		$\infty$		∞ 2e6	<i>i</i> 0/15
ABC	68(15)	89(32)	92(40)	92(37)	92(23)	92(29)	92(24)	15/15	ABC	34(24)	~	> 1	~ +1	~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	+1	~	4	∞ 2e6	0/15
SSEABC	25(7)	74(29)	107(77)	145(106)	190(142)	245(195)	282(46)	15/15	SSEABC	3.1(1.0)		0.95(0.2)	1.3(2) **	1.8(2)	16(2	2) * 4	<b>50</b> (48) ^	4	∞ 2e5	0/15
	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1		1e0	1e-1	1	2-2	1e-3		1e-5	1e-7	#succ
PSO	1296	2343	3413 705(735)	4255 586(942)	5220 502(619)	6/28 423(394)	8409 577(477)	5/15	f18	621		3972	1	9561	28555		57569	1.3e5	1.5e5	15/15
GA	1955(4251)	∞	∞	~	~	~	∞ 2e6	0/15	GA	236(1613) 76(11)		∞ 311(644)	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	0	0 0	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	00 2et	0/15
ABC	46(15)	453(260)	2587(2379)	~	~	~	∞ 2e6	0/15	ABC	4.6e4(5e4)		∞	~	•	•	~		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	∞ 2e6	5 0/15
SSEABC	1.3(0.2)*4	1.2(0.1) <sup>*4</sup>	1.1(0.1)**	4 <b>1.1</b> (0.1)*4	<b>1.1</b> (0.1) <sup>*4</sup>	1.1(0.1)*4	1.1(0.0) <sup>*4</sup>	15/15	SSEABC	1.1(0.4)*	4	0.76(0.1)*	<sup>4</sup> 1.1(0.9)	*4 31	(41)*4	20(17)	<del>*</del> 4	$\infty$	∞ 2e5	5 0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1					1e0	1e-1	1e-2 1e	-3 1e-5	1e-7	#succ
f7	1351	4274	9503	16523	16524	16524	16969	15/15	f19			1	L		1	3.4e5	4.7e6 6.2	e6 6.7e6	6.7e6	15/15
PSO	427(776) 77(8)	~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~	~	~	∞ 2e6 ∞ 2e6	0/15	PSO	382(192)					<b>∞</b>	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	$\infty \propto$	~ ~~	∞ 2e6	0/15
ABC	251(319)	~	~	~	~	~	∞ 2e6 ∞ 2e6	0/15	GA	1.4e4(3172)					6.5e5(8e	!) ∞ ∞	~ ~	~~~~	∞ 2e6	0/15
SSEABC	0.94(0.2)*4	5.0(2)*4	3.4(0.7) <sup>*4</sup>	2.1(0.6)*4	2.1(0.0)*4	2.1(0.3) *4	2.1(0.3)*4	15/15	SSFARC	329(60)					4 704(40	1)*4 ∞	~ ~	, ~~	~ 2ec	5 0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	Af .	101			1e0		4.704(40	10-1	10-2 10	-3 10-5	10-7	l#ence
	2039	3871	4040	4148	4219	4371	4484	15/15	f20	101	8	32	100	461	50	3.1ef	5.5e6 5.5	e6 5 6ef	5.6e6	14/15
PSO	90(41)	307(305)	350(436)	406(574)	466(205)	894(1065)	3276(5241)	1/15	PSO	17(4)			50(65)			$\infty$	$\infty \propto$	~ ~~	∞ 2e6	0/15
GA	∞ 2.0(2)	∞ 5.0(2)	∞ 10(2)	27(28)	252(285)	~	∞ 2e6 ∞ 2e6	0/15	GA	502(60)			2.8(0.3	s)		$\infty$	$\infty \propto$	~ ~~	∞ 2e6	i 0/15
SSFARC	4 1(0.9)	5.7(6)	5 9(6)*	8 4(12) * 2	12(18)*3	34(20)*3	68(192)*3	7/15	ABC	16(5)			0.12(0	.1)*5		$\infty$	$\infty \propto$	~ ~	∞ 2e6	0/15
AF .	1.1(0.7)	1e0	10-1	10-2	12(10)	16-5	10-7	###100	SSEABC	6.9(1.0)*	4		62(63)			$\infty$	$\infty \propto$	~ ~	∞ 2e5	0/15
fo	1716	3102	3277	3370	3455	3504	3727	15/15	$\Delta f_{opt}$	1e1	1e0	) :	1e-1	1e-2	1e-3	1e-5		1e-7		#succ
PSO	670(245)	~	~	~	~	~	∞ 2e6	0/15	f21	561	100	6541	14103	14318	14643	1	5567	17	589	15/15
GA	∞	~	$\infty$	$\infty$	$\infty$	$\infty$	∞ 2e6	0/15	GA	90(41)	428	1(4434) 1 5(612)	3986(1985)	397(455)	904(1162)	1/99(	1831)	1593(20 co 2e6	)4/) ;	0/15
ABC	699(538)	∞ ★4	∞ ★4	∞ ★4	∞ +4	∞ ★4	∞ 2e6 ★4	0/15	ABC	5.0(3)	22	2(52)	25(45)	26(46)	27(26)	35(	59)	85(10	)4)	8/15
SSEABC	4.6(0.6) ···	6.1(8) <sup>~~</sup>	<b>6.5</b> (0.4) <sup>7,1</sup>	12(4)	17(29)	38(38)	70(71)	4/15	SSEABC	4.6(5)	2	9(12)	203(152)	200(206)	195(260)	184(	167)	163(31	16)	1/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1		1e0	1	e-1	1e-2		1e-1	3 1e-5	1e-7	#succ
f10 PSO	7413	8661	10735	13641	14920	17073	17476	15/15	f22	46	7	5	580	23491		24163	2494	18 26847	1.3e5	12/15
GA	~	~	~	~	~	~	∞ 2e6	0/15	PSO GA	5.0(10) 110(39)		411(897) 1452(718)	c	io in	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	$\infty 2ec$	0/15
ABC	∞	∞	∞ .	∞ .	∞ .	∞ .	∞ 2e6	0/15	ABC	10(6)		47(71)	7:	7(57)	578(55	9)	~	~	∞ 2e6	5 0/15
SSEABC	1.8(0.3) <sup>*4</sup>	1.9(0.2) <sup>*4</sup>	1.7(0.1) <sup>*4</sup>	1.7(1) <sup>*4</sup>	3.7(2) <sup>*4</sup>	<b>13</b> (11) <sup>*4</sup>	80(74) <sup>*4</sup>	0/15	SSEABC	70(298)		77(105)	c	o	∞ `		$\infty$	$\infty$	∞ 2e5	0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1		1e0		16	-1		1e-2 1e	-3 1e-5	1e-7	#succ
f11	1002	2228	6278	8586	9762	12285	14831	15/15	f23		3.0		1614		67457		3.7e5 4.9	e5 8.1e5	8.4e5	15/15
PSO GA	143(56) 2.9e4(2c4)	186(32)	109(13)	114(15)	132(14)	148(13)	2019(2596) 206	0/15	PSO GA	2.4(2)		1554	(1433)	•	0		~ ~	> ~~	∞ 2e6	0/15
ABC	2.7€4(J84) ∞	~	~	~	~	~	∞ 2e0 ∞ 2e6	0/15	ABC	1.2(0.9)		4570	(63)	0	5		$\infty \propto \infty$	, 30	∞ 2et	5 0/15
SSEABC	<b>10</b> (0.4)*4	5.0(0.2)*4	1.9(0.1)*4	1.5(0.0) *4	1.4(0.0)*4	1.2(0.0)*4	1.0(0.0)*4	15/15	SSEABC	2.1(2)		31	(24)	4.	9(5) <sup>*2</sup>		~ ~	~ ~	∞ 2e5	5 0/15
$\Delta f_{opt}$	1e1	1e0	1e-1	1e-2	1e-3	1e-5	1e-7	#succ	$\Delta f_{opt}$	1e1 1e0	1e-1 1e	e-2 1e-3 1e-	5 1e-7 #suco							
f12	1042	1938	2740	3156	4140	12407	13827	15/15	f24	1.3e6 7.5e6	5.2e7 5.2	2e7 5.2e7 5.2e	7 5.2e7 3/15							
PSO	1703(2413)	$\infty$	$\infty$	8	~	~	∞ 2e6	0/15	PSO	∞ ∞	$\infty \propto$	• • •	∞ 2e6 0/15							
GA	26(5)	∞ (7(122)	∞ 420(201)	∞ 2184(2212)	∞ 7242/1-4)	~	∞ 2e6 ∞ 2e6	0/15	GA	~ ~	~ ~	• • • •	∞ 2e6 0/15							
SCEADO	20(3)	3 3(2) *4	3 9(2)*4	2104(3212) 5 2(1)*4	6 0(7)*4	63(2)*4	19(22)*4	6/15	SSEABC	$\infty \infty$	∞ ∞	~ ~ ~ ~	$\infty 2e6 0/15$ $\infty 2e5 0/15$							
JJLADU	2.0(4)	3.3(3)	3.9(2)	3.2(1)	0.0(7)	0.3(2)	19(22)	0/15												

Table 3: Average runtime (aRT in number of function evaluations) divided by the respective best aRT measured during BBOB-2009 in dimension 20. The aRT and in braces, as dispersion measure, the half difference between 10 and 90%-tile of bootstrapped run lengths appear for each algorithm and target, the corresponding reference aRT in the first row. The different target  $\Delta f$ values are shown in the top row. #succ is the number of trials that reached the (final) target  $f_{opt} + 10^{-8}$ . The median number of conducted function evaluations is additionally given in *italics*, if the target in the last column was never reached. Entries, succeeded by a star, are statistically significantly better (according to the rank-sum test) when compared to all other algorithms of the table, with p = 0.05 or  $p = 10^{-k}$  when the number k following the star is larger than 1, with Bonferroni correction of 110. A  $\downarrow$  indicates the same tested against the best algorithm from BBOB 2009. Best results are printed in bold. Data produced with COCO v2.1