Test of Planck.jl, EmPoint type from BandPyrometry.jl and JDXreader.jl

Contents

- Planck functions
- Optimization of BB temperature with and without the EmPoint type
- JDXreader test

Testing main functionality of Planck module functions

Plotting blackbody spectrum and its derivarives

Set wavelength region:

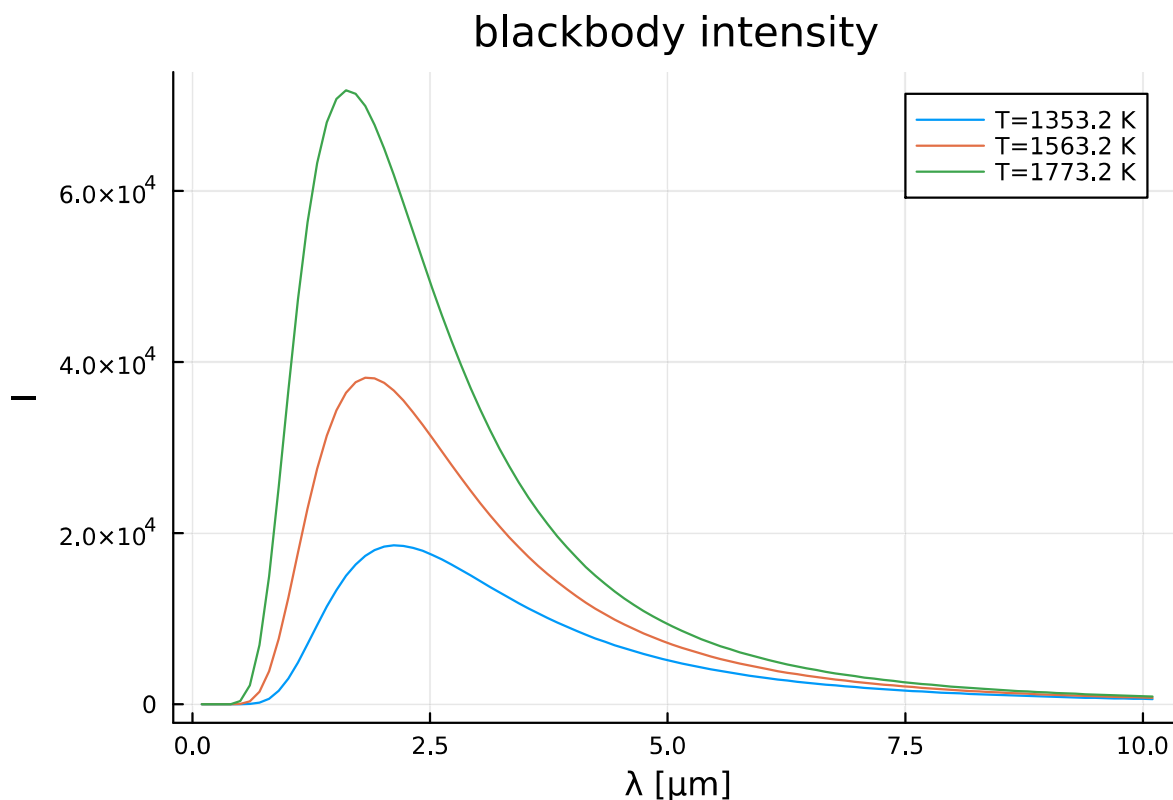wavelength region left boundary, λ_l = ⬤━━━━━ 0.1 [Submit]

wavelength region right boundary λ_r = ━⬤━━━━ 10.1 [Submit]

T_1 = ━━⬤━━━━ 1080.0 T_2 = ━━━⬤━━ 1290.0 T_3 = ━━━⬤━ 1500.0

Table of fraction of total power within spectral range 0.1 … 10.1

Temperature	Fractional power
1353.15	0.9302
1563.15	0.939883
1773.15	0.94567

("blackbody intensity", "I", Main.BandPyrometry.Planck.ibb)   ⌄

BB temperature fitting using Planck module and EmPoint type from BandPyrometry module

Least square discrepancy:
$$r(T) = \sum_i (I_{bb}(\lambda_i, T) - I_{bb}(\lambda_i, T_{real}))^2$$

$I_{bb}(\lambda, T)$ is the blackbody spectrum

Blackbody real temperature T_{real} to be fitted (Celsius) ●―――――― 500.0 [Submit]

Set the value of T_{try} to calculate $r(T_{try}), \nabla_T r(T_{try}), \nabla_T^2 r(T_{try})$ manually (Celsius)
●―――― 500.5

Table of discrepancy and its derivatives values, calculated for T=773.65,K

calculated using:	discrepancy	gradient	hessian
Direct	1.72071e7	2.31088e5	2578.94
EmPoint	1.72071e7	2.31088e5	2578.94
AutoDiff	–	2.31088e5	2578.94

Try zero order method fitting = ☑ Submit

Zero order optimizer ("NelderMead", Optim.NelderMead) ⌄

Tres direct = 499.99997019579797

Tres EmPoint = 500.0000028729439

show zero order output = ☑

```
 * Status: success

 * Candidate solution
   Final objective value:      3.291167e-08

 * Found with
   Algorithm:      Fminbox with Nelder-Mead

 * Convergence measures
   |x - x'|              = 0.00e+00 ≤ 0.0e+00
   |x - x'|/|x'|         = 0.00e+00 ≤ 0.0e+00
   |f(x) - f(x')|        = 0.00e+00 ≤ 0.0e+00
   |f(x) - f(x')|/|f(x')| = 0.00e+00 ≤ 0.0e+00
   |g(x)|               = 2.33e+02 ≰ 1.0e-08

 * Work counters
   Seconds run:   0  (vs limit Inf)
   Iterations:    4
   f(x) calls:    107
   ∇f(x) calls:   1
```
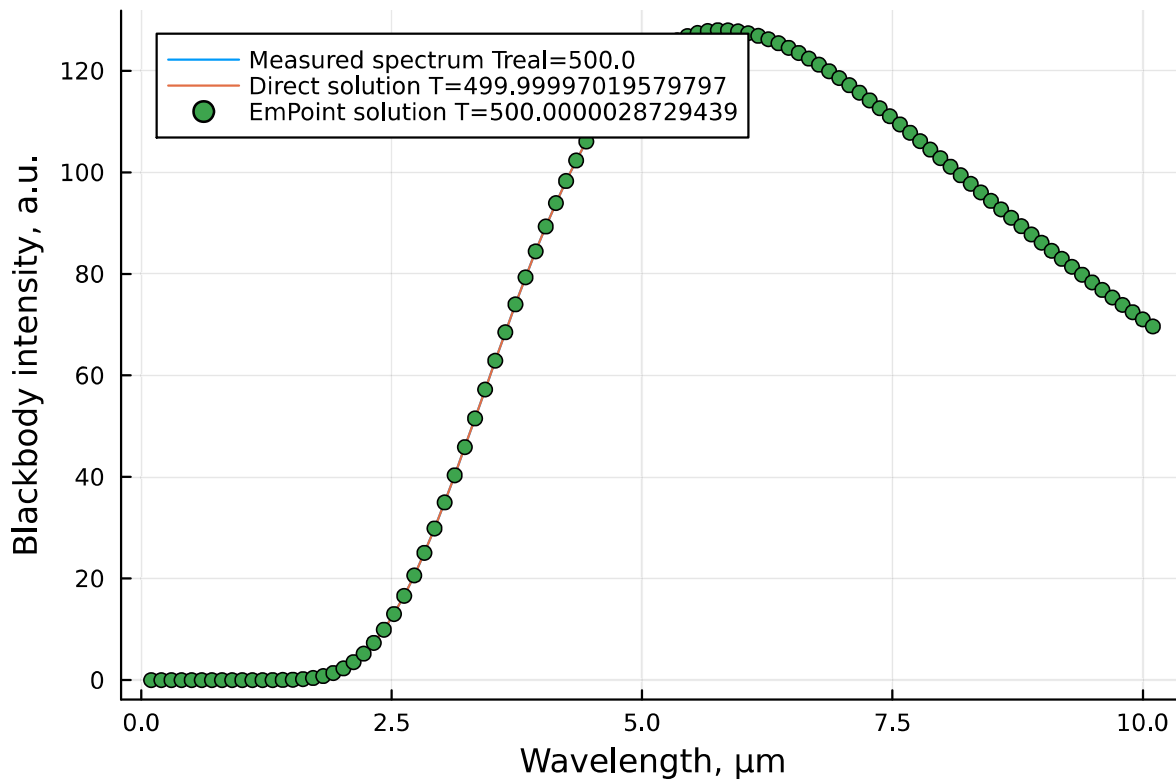
```
 * Status: success

 * Candidate solution
   Final objective value:      3.058084e-10

 * Found with
   Algorithm:      Nelder-Mead

 * Convergence measures
   √(Σ(yᵢ-ȳ)²)/n ≤ 1.0e-08

 * Work counters
   Seconds run:   0  (vs limit Inf)
   Iterations:    16
   f(x) calls:    35
```

run zero order benchmark = ☑

```
BenchmarkTools.Trial: 498 samples with 1 evaluation.
 Range (min … max):  6.621 ms … 62.741 ms  │ GC (min … max): 0.00% … 0.00%
 Time  (median):     9.555 ms              │ GC (median):    0.00%
 Time  (mean ± σ):   9.980 ms ±  3.727 ms  │ GC (mean ± σ):  0.47% ± 3.18%
```



```
  6.62 ms        Histogram: frequency by time          19 ms <
```

```
 Memory estimate: 208.50 KiB, allocs estimate: 2335.
```

```
BenchmarkTools.Trial: 1978 samples with 1 evaluation.
 Range (min … max):  1.583 ms … 32.151 ms  │ GC (min … max): 0.00% … 93.67%
 Time  (median):     1.820 ms              │ GC (median):    0.00%
 Time  (mean ± σ):   2.471 ms ±  1.428 ms  │ GC (mean ± σ):  0.62% ±  2.11%
```



```
  1.58 ms      Histogram: log(frequency) by time       6.86 ms <
```

```
 Memory estimate: 39.00 KiB, allocs estimate: 546.
```

Try first order method fitting = ☑ [Submit]

[("LBFGS", Optim.LBFGS)   ⌄]

SciMLBase.OptimizationSolution{Float64, 1, Vector{Float64}, OptimizationBase.OptimizationCac

Tres direct implementation= 500.0

Tres EmPoint= 500.0

show first order output = ☑

```
* Status: success

* Candidate solution
    Final objective value:      0.000000e+00

* Found with
    Algorithm:      L-BFGS

* Convergence measures
    |x - x'|               = 6.48e-06 ≰ 0.0e+00
    |x - x'|/|x'|          = 1.30e-08 ≰ 0.0e+00
    |f(x) - f(x')|         = 1.56e-09 ≰ 0.0e+00
    |f(x) - f(x')|/|f(x')| = Inf ≰ 0.0e+00
    |g(x)|                 = 8.17e-13 ≤ 1.0e-08

* Work counters
    Seconds run:   1  (vs limit Inf)
    Iterations:    5
    f(x) calls:    17
    ∇f(x) calls:   17


* Status: success

* Candidate solution
    Final objective value:      7.973466e-26

* Found with
    Algorithm:      L-BFGS

* Convergence measures
    |x - x'|               = 2.45e-09 ≰ 0.0e+00
    |x - x'|/|x'|          = 4.90e-12 ≰ 0.0e+00
    |f(x) - f(x')|         = 2.22e-16 ≰ 0.0e+00
    |f(x) - f(x')|/|f(x')| = 2.79e+09 ≰ 0.0e+00
    |g(x)|                 = 8.17e-13 ≤ 1.0e-08

* Work counters
    Seconds run:   0  (vs limit Inf)
    Iterations:    6
    f(x) calls:    17
    ∇f(x) calls:   17
```
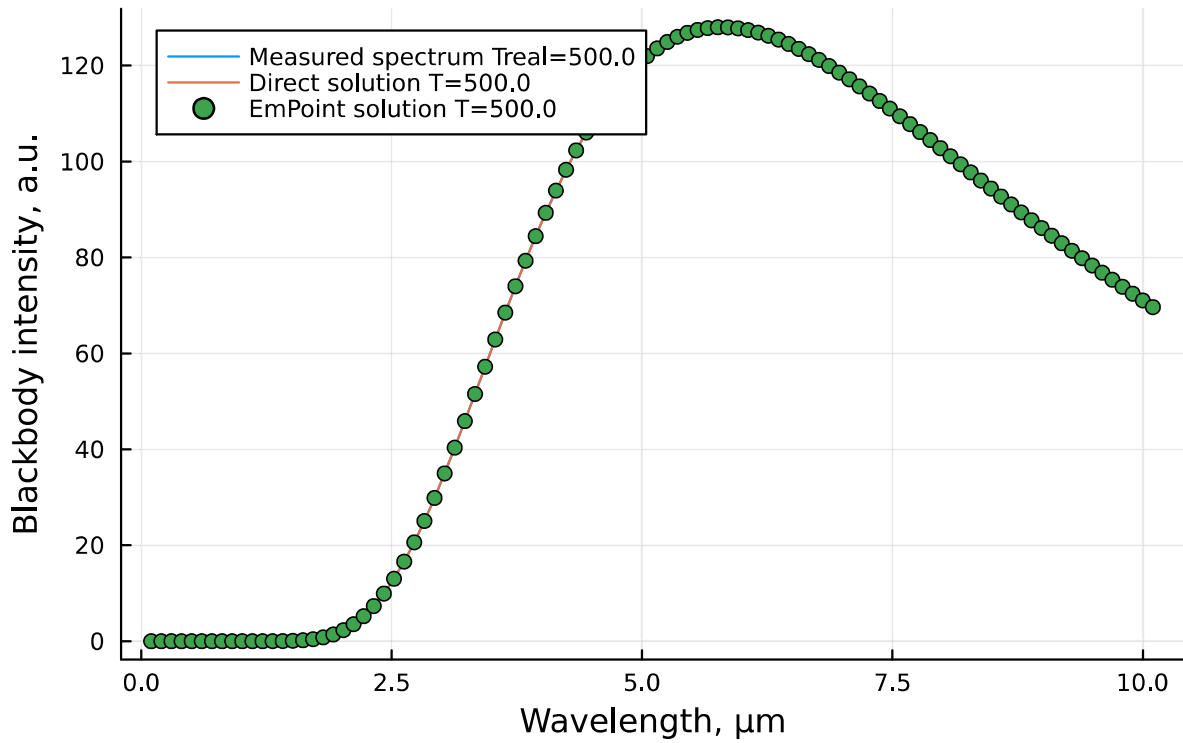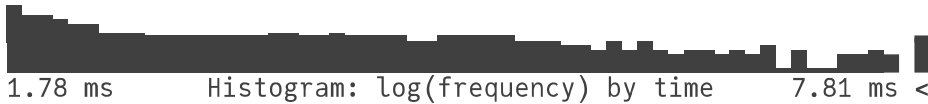
First order method LBFGS

run first order benchmark = ☑

```
BenchmarkTools.Trial: 1777 samples with 1 evaluation.
 Range (min … max):  1.776 ms … 16.881 ms │ GC (min … max): 0.00% … 87.14%
 Time  (median):     2.098 ms             │ GC (median):    0.00%
 Time  (mean ± σ):   2.767 ms ±  1.464 ms │ GC (mean ± σ):  1.11% ±  4.04%

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  1.78 ms       Histogram: log(frequency) by time      7.81 ms <

 Memory estimate: 171.72 KiB, allocs estimate: 637.
```

```
BenchmarkTools.Trial: 3170 samples with 1 evaluation.
 Range (min … max):  993.800 µs … 39.195 ms │ GC (min … max): 0.00% … 96.44%
 Time  (median):        1.145 ms            │ GC (median):    0.00%
 Time  (mean ± σ):      1.529 ms ±  1.110 ms │ GC (mean ± σ):  0.78% ±  1.71%

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  994 µs         Histogram: log(frequency) by time      4.49 ms <

 Memory estimate: 29.23 KiB, allocs estimate: 423.
```

Try second order method fitting = ☑ [Submit]

[("NewtonTrustRegion", Optim.NewtonTrustRegion) ⌄]

SciMLBase.OptimizationSolution{Float64, 1, Vector{Float64}, OptimizationBase.OptimizationCach

◀ ▭▭▭   ▶

Tres direct implementation= 500.0

Tres EmPoint= 500.0

show second order output = ☑

* Status: success

* Candidate solution
  Final objective value: 0.000000e+00

* Found with
  Algorithm: Newton's Method (Trust Region)

* Convergence measures
  $|x - x'|$ = 3.74e-08 ≰ 0.0e+00
  $|x - x'|/|x'|$ = 7.47e-11 ≰ 0.0e+00
  $|f(x) - f(x')|$ = 5.18e-14 ≰ 0.0e+00
  $|f(x) - f(x')|/|f(x')|$ = Inf ≰ 0.0e+00
  $|g(x)|$ = 8.17e-13 ≤ 1.0e-08

* Work counters
  Seconds run: 0 (vs limit Inf)
  Iterations: 15
  f(x) calls: 16
  ∇f(x) calls: 16
  ∇²f(x) calls: 15

* Status: success

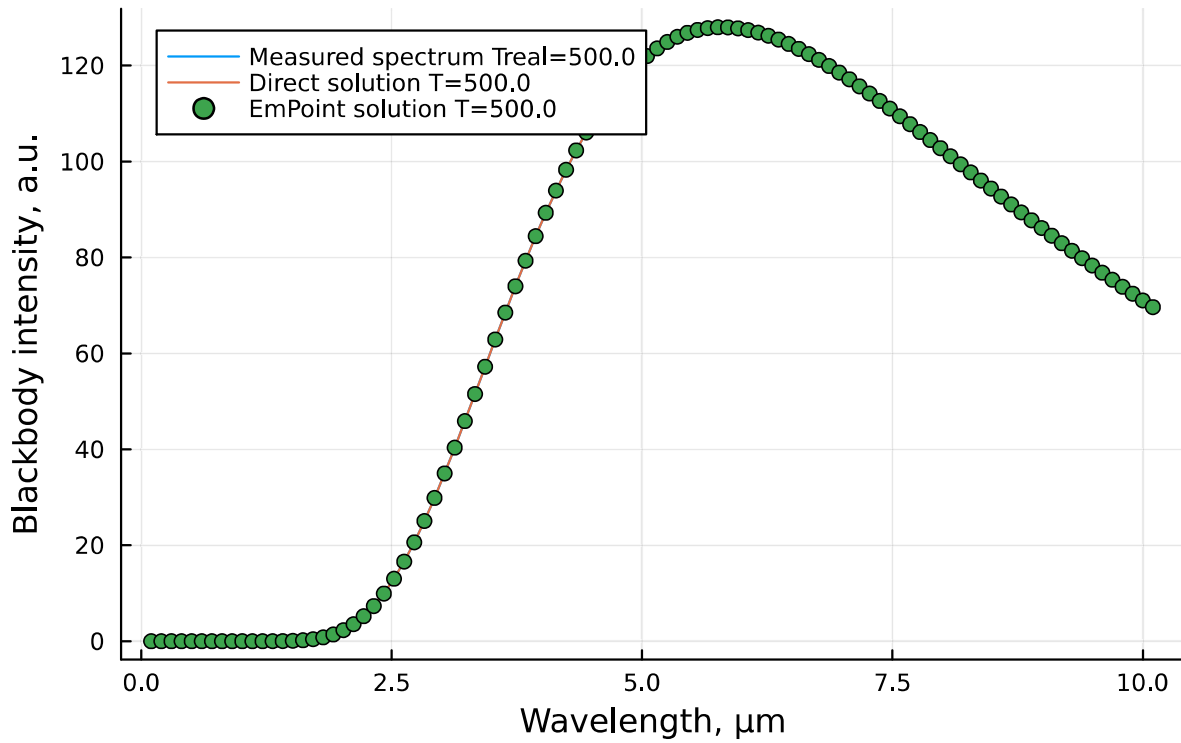* Candidate solution
  Final objective value: 7.973466e-26

* Found with
  Algorithm: Newton's Method (Trust Region)

* Convergence measures
  $|x - x'|$ = 2.98e-08 ≰ 0.0e+00
  $|x - x'|/|x'|$ = 5.97e-11 ≰ 0.0e+00
  $|f(x) - f(x')|$ = 3.30e-14 ≰ 0.0e+00
  $|f(x) - f(x')|/|f(x')|$ = 4.14e+11 ≰ 0.0e+00
  $|g(x)|$ = 8.17e-13 ≤ 1.0e-08

* Work counters
  Seconds run: 0 (vs limit Inf)
  Iterations: 15
  f(x) calls: 16
  ∇f(x) calls: 16
  ∇²f(x) calls: 16

First order method NewtonTrustRegion

run second order benchmark = ☑

```
BenchmarkTools.Trial: 920 samples with 1 evaluation.
 Range (min … max):  3.163 ms … 27.577 ms │ GC (min … max): 0.00% … 72.91%
 Time  (median):     4.500 ms              │ GC (median):    0.00%
 Time  (mean ± σ):   5.371 ms ±  2.346 ms  │ GC (mean ± σ):  1.15% ±  4.22%
```



```
 3.16 ms         Histogram: frequency by time        11.4 ms <
```

```
 Memory estimate: 247.06 KiB, allocs estimate: 1228.
```

```
BenchmarkTools.Trial: 1936 samples with 1 evaluation.
 Range (min … max):  1.557 ms … 59.662 ms │ GC (min … max): 0.00% … 96.62%
 Time  (median):     1.889 ms              │ GC (median):    0.00%
 Time  (mean ± σ):   2.525 ms ±  1.850 ms  │ GC (mean ± σ):  1.18% ±  2.20%
```



```
 1.56 ms      Histogram: log(frequency) by time       6.61 ms <
```

```
 Memory estimate: 57.47 KiB, allocs estimate: 869.
```

| Optimizer	time Direct, ms	time EmPoint, ms
LBFGS	2.76654	1.52919
Newton	2.95612	1.14428
NelderMead	9.9801	2.47128
GradientDescent	1.88965	1.65879
NewtonTrustRegion	5.37063	2.52511
BFGS	2.79822	1.52813
ParticleSwarm	342.364	188.184

Select benchmarks to compare

LBFGS
Newton
NelderMead
GradientDescent
NewtonTrustRegion
BFGS
ParticleSwarm   Submit

Performance of direct impelementation vs EmPoint type
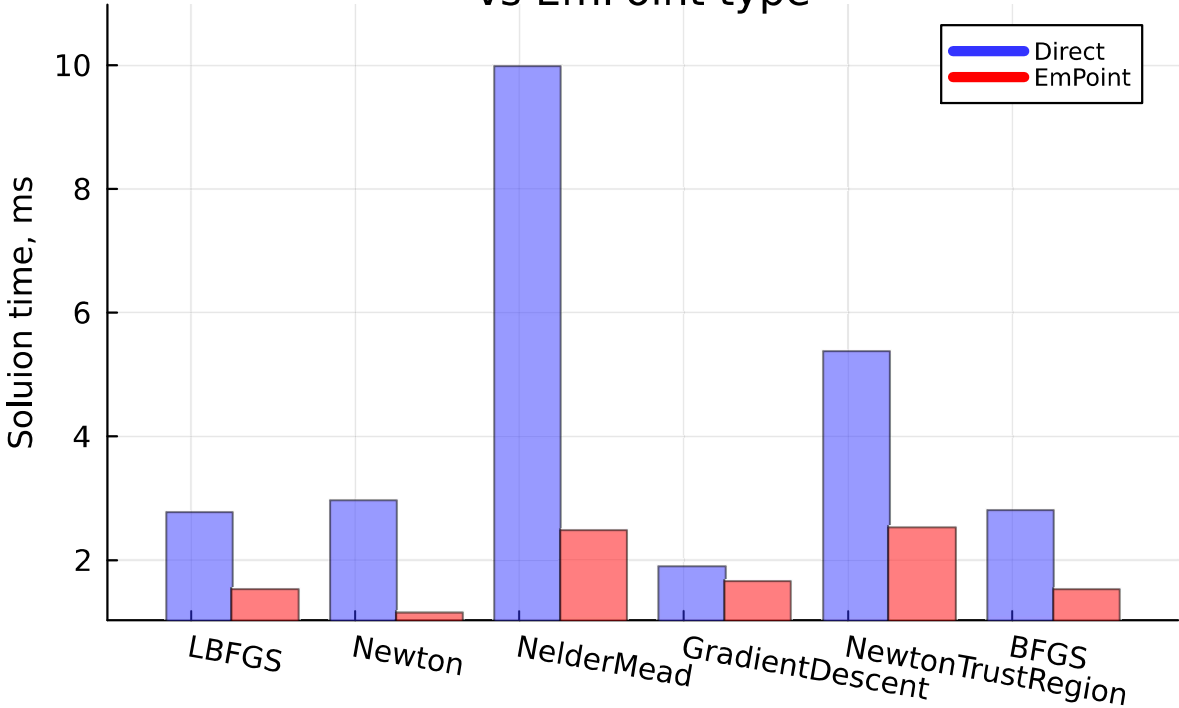
Load jdx file? ☑ Submit

This figure show measured spectrum loaded using JDXreader

INFRARED SPECTRUM