WOLFRAM MATHEMATICA 13.0 aer

setup

overhead

tag

```
In[ ]:= home = "topics/aer/truth/";
        Get["utility modules.m", Path → dirPack];
        stamp1;
```

CreateDirectory: /Users/dtopa/Mathematica_files/io/ already exists.

CreateDirectory: /Users/dtopa/Dropbox/_mm/io/topics/ already exists.

CreateDirectory: /Users/dtopa/Dropbox/_mm/io/topics/aer/ already exists.

General: Further output of CreateDirectory::eexist will be suppressed during this calculation.

```
maximum memory: 0.0910244 GB
seed file: /Users/dtopa/Mathematica_files/nb/seed 22_01.nb
user: dtopa, CPU: ehecoatl,  MM v. 13.0.0 for Mac OS X x86
date: Feb 8, 2022, time: 10:52:31
nb: /Users/dtopa/Mathematica_files/nb/topics/aer/truth/rept-reader-02.nb
```

modules, functions, settings, ...

1 gather

strings

```
In[ ]:= dirHeatMaps = "/Volumes/Tlaloc/spacktivity/REPT Data/";
        fileNameLeft = "rbspa_rel03_ect-rept-sci-L3_";
        fileNameRight = ".cdf";
```

specific days

```
In[ ]:= days = {"20170207_v5.1.0", "20170425_v5.5.0",
           "20170620_v5.3.0", "20170917_v5.3.0", "20171214_v5.3.0"};
```

2

data structure

In[•]:=
```
A = Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight]
```

Out[•]=
```
{Epoch, Epoch_prot, FEDU_Alpha_DELTA, FEDU_Alpha, FEDU_0to180_Alpha,
 FEDU_180to360_Alpha, FPDU_Alpha, FPDU_0to180_Alpha, FPDU_180to360_Alpha,
 FEDU_Unbinned_Sector_Angle, FEDU_Unbinned_Alpha_DELTA, FEDU_Unbinned_Alpha,
 FEDU_Unbinned_Alpha360, FPDU_Unbinned_Sector_Angle, FPDU_Unbinned_Alpha_DELTA,
 FPDU_Unbinned_Alpha, FPDU_Unbinned_Alpha360, FEDU_Energy, FEDU_Energy_DELTA_minus,
 FEDU_Energy_DELTA_plus, FEDU_PA_LABL, FEDU_PA_0TO180_LABL, FEDU_PA_180TO360_LABL,
 FEDU_ENERGY_LABL, FEDU, FPDU_PA_LABL, FPDU_PA_0TO180_LABL, FPDU_PA_180TO360_LABL,
 FPDU_ENERGY_LABL, FPDU, FPDU_Energy, FEDU_0to180, FEDU_180to360,
 FPDU_0to180, FPDU_180to360, FEDU_Unbinned_0to180, FEDU_Unbinned_0to360,
 FPDU_Unbinned_0to180, FPDU_Unbinned_0to360, FPDU_Unbinned_LightMask_0to360,
 FPDU_Unbinned_Light_Flag, L_star, L, I, B_Calc, B_Eq, MLT, MLAT, Position}
```

In[•]:=
```
Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight, "Elements"]
```

Out[•]=
```
{Annotations, Data, DataEncoding, DataFormat, Datasets, Metadata}
```

metadata

dataset names

In[•]:=
```
dataSetNames = Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight]
m = Length[%]
```

Out[•]=
```
{Epoch, Epoch_prot, FEDU_Alpha_DELTA, FEDU_Alpha, FEDU_0to180_Alpha,
 FEDU_180to360_Alpha, FPDU_Alpha, FPDU_0to180_Alpha, FPDU_180to360_Alpha,
 FEDU_Unbinned_Sector_Angle, FEDU_Unbinned_Alpha_DELTA, FEDU_Unbinned_Alpha,
 FEDU_Unbinned_Alpha360, FPDU_Unbinned_Sector_Angle, FPDU_Unbinned_Alpha_DELTA,
 FPDU_Unbinned_Alpha, FPDU_Unbinned_Alpha360, FEDU_Energy, FEDU_Energy_DELTA_minus,
 FEDU_Energy_DELTA_plus, FEDU_PA_LABL, FEDU_PA_0TO180_LABL, FEDU_PA_180TO360_LABL,
 FEDU_ENERGY_LABL, FEDU, FPDU_PA_LABL, FPDU_PA_0TO180_LABL, FPDU_PA_180TO360_LABL,
 FPDU_ENERGY_LABL, FPDU, FPDU_Energy, FEDU_0to180, FEDU_180to360,
 FPDU_0to180, FPDU_180to360, FEDU_Unbinned_0to180, FEDU_Unbinned_0to360,
 FPDU_Unbinned_0to180, FPDU_Unbinned_0to360, FPDU_Unbinned_LightMask_0to360,
 FPDU_Unbinned_Light_Flag, L_star, L, I, B_Calc, B_Eq, MLT, MLAT, Position}
```

Out[•]=
```
49
```

LaTeX

3 import data sets

epochs

In[•]:=
```
{α, β} = Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight,
  {"Datasets", {"Epoch", "Epoch_prot"}}]
```

Out[•]=

```
{{{2017, 2, 7, 0, 0, 6.164}, {2017, 2, 7, 0, 0, 16.916}, {2017, 2, 7, 0, 0, 27.667},
  {2017, 2, 7, 0, 0, 38.419}, ··· 8027 ···, {2017, 2, 7, 23, 59, 17.072},
  {2017, 2, 7, 23, 59, 27.824}, {2017, 2, 7, 23, 59, 38.576}}, {··· 1 ···}}
```

large output | show less | show more | show all | set size limit...

In[•]:=
```
{m, n} = Dimensions[α]
```

Out[•]=
```
{8034, 6}
```

In[•]:=
```
epochL = 86400/8034
% // N
```

Out[•]=
$$\frac{14400}{1339}$$

Out[•]=
```
10.7543
```

In[•]:=
```
α[[1]]
α[[2]]
α[[3]]
α[[m]]
```

Out[•]=
```
{2017, 2, 7, 0, 0, 6.164}
```

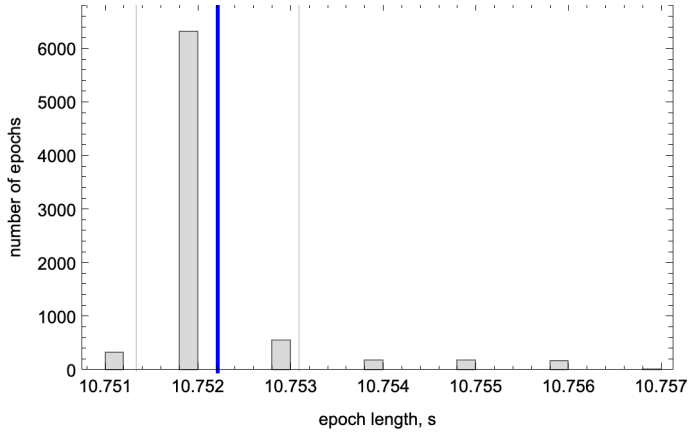
Out[•]=
```
{2017, 2, 7, 0, 0, 16.916}
```

Out[•]=
```
{2017, 2, 7, 0, 0, 27.667}
```

Out[•]=
```
{2017, 2, 7, 23, 59, 38.576}
```

```
In[•]:= β[[1]]
        β[[2]]
        β[[3]]
        β[[m]]
Out[•]=
        {2017, 2, 7, 0, 0, 6.164}
Out[•]=
        {2017, 2, 7, 0, 0, 16.916}
Out[•]=
        {2017, 2, 7, 0, 0, 27.667}
Out[•]=
        {2017, 2, 7, 23, 59, 38.576}

In[•]:= 60 - 49.248`
Out[•]=
        10.752

In[•]:= diff = Table[
            Last[α[[k + 1]]] - Last[α[[k]]]
            , {k, m - 1}];

In[•]:= tdiff = If[# < 0, # + 60, #] & /@ diff;

In[•]:= μ = Mean[tdiff]
        σ = StandardDeviation[tdiff]
Out[•]=
        10.7522
Out[•]=
        0.000879782

In[•]:= gh = Histogram[tdiff,
            FrameLabel → {"epoch length, s", "number of epochs"},
            ChartStyle → LightGray,
            Frame → True];

In[•]:= gμ = Graphics[{Blue, Thick, Line[{{μ, 1}, {μ, 10 000}}]}];
        gσl = Line[{{μ - σ, 1}, {μ - σ, 10 000}}];
        gσr = Line[{{μ + σ, 1}, {μ + σ, 10 000}}];
        gσ = Graphics[{Thin, Gray, gσl, gσr}];
```

In[•]:=
```
gepochΔ = Show[{gh, gμ, gσ}, PlotRange → {Automatic, {0, 6500}}]
```



In[•]:=
```
Commonest[tdiff, 16]
```

Out[•]=
```
{10.752, 10.751, 10.752, 10.751, 10.752, 10.751, 10.753, 10.753,
 10.753, 10.754, 10.754, 10.754, 10.755, 10.755, 10.755, 10.756}
```

In[•]:=

In[•]:=
```
α[[2]] - α[[1]]
FortranForm[Last[%]]
```

Out[•]=
```
{0, 0, 0, 0, 0, 10.752}
```

Out[•]//FortranForm=
```
10.752
```

In[•]:=
```
Commonest[{0, 0, 0, 0, 0, 10.752}]
```

Out[•]=
```
{0}
```

In[•]:=
```
α - β
Norm[%]
```

Out[•]=
```
{{0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.},
 {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.},
 ··· 8022 ···, {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.},
 {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.}, {0, 0, 0, 0, 0, 0.}}
```

large output | show less | show more | show all | set size limit...

Out[•]=
```
0.
```

In[•]:=
```
16.916` - 6.164`
```
Out[•]=
```
10.752
```

In[•]:=
```
24 × 60 × 60
```
Out[•]=
```
86 400
```

In[•]:=
$$\frac{24 \times 60 \times 60}{16.916` - 6.164`}$$
Out[•]=
```
8035.71
```

magnetic field

In[•]:=
```
{Lstar, L, I, Bcalc, Beq} =
  Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight,
   {"Datasets", {"L_star", "L", "I", "B_Calc", "B_Eq"}}];
```

In[•]:=
```
Dimensions[%]
```
Out[•]=
```
{5, 8034}
```

In[•]:=
```
B = Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight,
   {"Datasets", {"L_star", "L", "I", "B_Calc", "B_Eq"}}]
Dimensions[%]
```
Out[•]=
```
{ … 1 … }
```
large output | show less | show more | show all | set size limit...

Out[•]=
```
{5, 8034}
```

L*

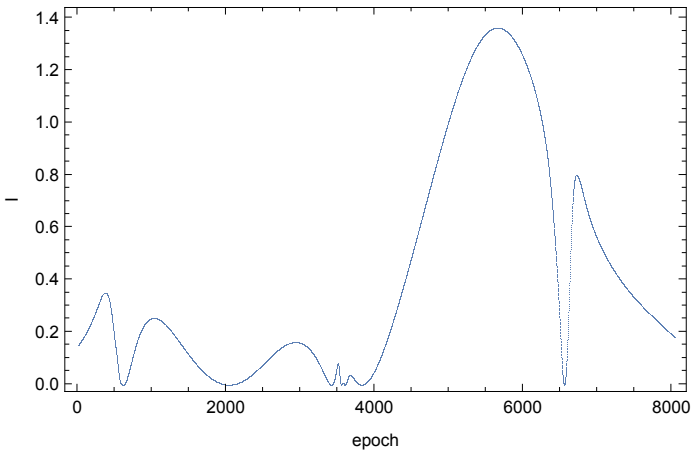
In[•]:=
```
g000 = ListPlot[Lstar,
    FrameLabel → {"epoch", "L*"},
    Frame → True];
```

L

In[•]:=
```
g001 = ListPlot[L,
    FrameLabel → {"epoch", "L"},
    Frame → True];
```

```
In[•]:= Show[
          {ListPlot[L, PlotStyle → {{Blue, Opacity[0.05]}}]},
          {ListPlot[Lstar, PlotStyle → {{Red, Opacity[0.05]}}]},
          FrameLabel → {"epoch", ""},
          Frame → True
         ];

In[•]:= g002a = ListPlot[{Lstar, L}, PlotStyle → {{Red, Opacity[0.75], PointSize[0.002]},
            {Blue, Opacity[0.75], PointSize[0.002]}}, PlotLegends → {"L*", "L"},
          Frame → True];

In[•]:= ratio = ToString["L" / "Lstar"];
        glratio = ListPlot[ L / Lstar ,
          FrameLabel → {"epoch", ratio},
          PlotRange → {Automatic, Full},
          Frame → True ];

In[•]:= g003 = ListPlot[I,
          FrameLabel → {"epoch", "I"},
          Frame → True]
```

Out[•]=




```
In[•]:= g004 = ListPlot[Bcalc,
          PlotRange → All,
          FrameLabel → {"epoch", "B_calc"},
          Frame → True];
```

discover local maxima

first

In[•]:=
```
list = B[[4]];
```

In[•]:=
```
First@Flatten@Position[list, Max[list]]
```

Out[•]=
```
553
```

second

In[•]:=
```
Max[B[[4]]]
```

Out[•]=
```
31 104.5
```

In[•]:=
```
list = B[[4]];
```

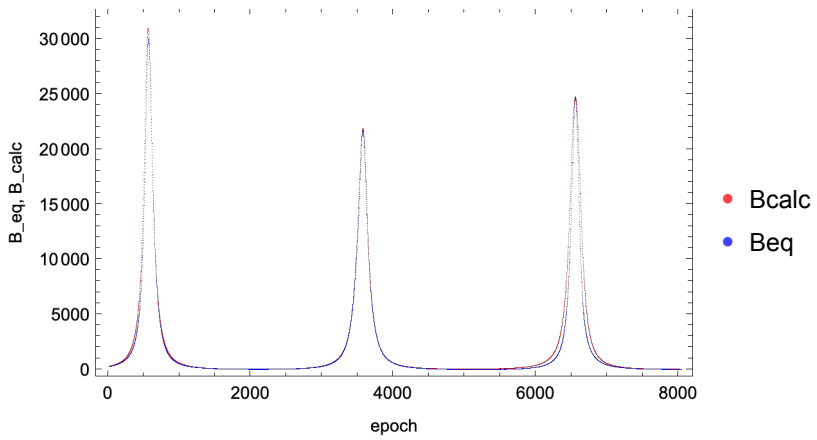
In[•]:=
```
Position[list, Max[list]]
```

Out[•]=
```
{{553}}
```

In[•]:=
```
g005 = ListPlot[Beq,
    PlotRange → All,
    FrameLabel → {"epoch", "B_eq"},
    Frame → True];
```

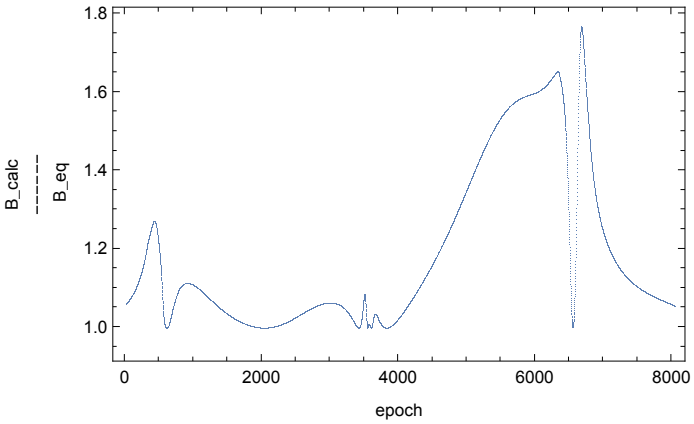
In[•]:=
```
gbfields = ListPlot[{Bcalc, Beq},
  PlotStyle → {{Red, Opacity[0.75], PointSize[0.002]}, {Blue, Opacity[0.75],
     PointSize[0.002]}}, FrameLabel → {"epoch", "B_eq, B_calc"},
  PlotLegends → {"Bcalc", "Beq"},
  PlotRange → {Automatic, Full},
  Frame → True]
```

Out[•]=



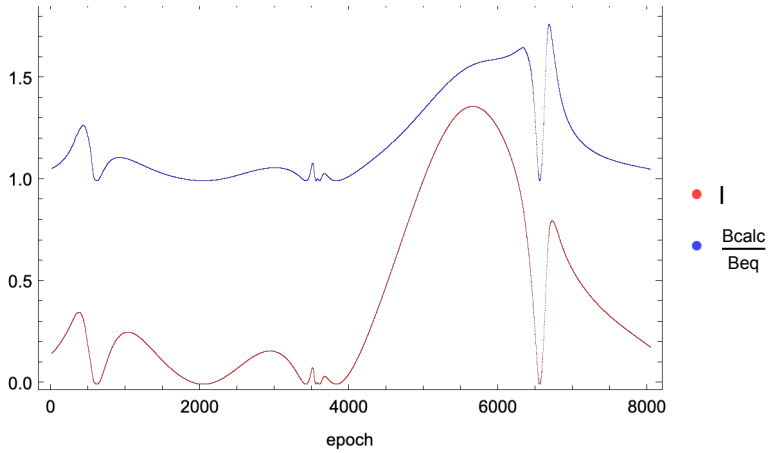
In[•]:=
```
ratio = ToString["B_calc" / "B_eq"];
gbratio = ListPlot[Bcalc/Beq,
  FrameLabel → {"epoch", ratio},
  PlotRange → {Automatic, Full},
  Frame → True]
```

Out[•]=



In[•]:=
```
gtwins = ListPlot[{I, Bcalc/Beq}, PlotStyle → {{Red, Opacity[0.75], PointSize[0.002]},
   {Blue, Opacity[0.75], PointSize[0.002]}}, FrameLabel → {"epoch", ""},
  PlotLegends → {"I", "Bcalc/Beq"},
  PlotRange → {Automatic, Full},
  Frame → True]
```

Out[•]=



Danny visits

In[∘]:=
```
fpdu = Import[
  dirHeatMaps <> fileNameLeft <> days⟦1⟧ <> fileNameRight, {"Datasets", {"FPDU"}}]
Dimensions[%]
```

Out[∘]=

{ … 1 … }

large output | show less | show more | show all | set size limit...

Out[∘]=

{8034, 17, 8}

In[∘]:=
```
ArrayPlot[fpdu⟦100⟧]
Norm[fpdu⟦1⟧, 2]
```

In[∘]:=
```
fpdu⟦10⟧ // mf
```

Out[∘]//MatrixForm=

$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$	$-1.\times10^{31}$

In[∘]:=
```
fpduEnergy = Import[dirHeatMaps <> fileNameLeft <> days⟦1⟧ <> fileNameRight,
  {"Datasets", {"FPDU_Energy"}}]
Dimensions[%]
```

Out[∘]=

{{21.25, 27.6, 35.9, 46.7, 60.7, 78.9, 102.6, 208.}}

Out[∘]=

{1, 8}

```
In[•]:= fpduEnergyLabel = Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight,
          {"Datasets", {"FPDU_ENERGY_LABL"}}]
        Dimensions[%]
Out[•]=
        {{21.25 MeV, 27.6 MeV, 35.9 MeV, 46.7 MeV, 60.7 MeV, 78.9 MeV, 102.6 MeV, 208 MeV}}
Out[•]=
        {1, 8}

In[•]:= Import[dirHeatMaps <> fileNameLeft <> days[[1]] <> fileNameRight,
         {"Datasets", {"FPDU_Unbinned_Light_Flag"}}]
In[•]:= Dimensions[%]
Out[•]=
        {8034}

In[•]:= Norm[%%, 2]
Out[•]=
        0
```

export

graphics

```
In[•]:= multiExport["dataset-epoch-length", gepochΔ]
In[•]:= multiExport["dataset-L*", g000]
In[•]:= multiExport["dataset-L,L*", g002a]
In[•]:= multiExport["dataset-Lratio", glratio]
In[•]:= multiExport["dataset-I", g003]
In[•]:= multiExport["dataset-B_calc", g004]
In[•]:= multiExport["dataset-Beq", g005]
In[•]:= multiExport["dataset-B_fields", gbfields]
In[•]:= multiExport["dataset-B_ratio", gbratio]
In[•]:= multiExport["dataset-twins", gtwins]
```

data

```
In[•]:= Export[dirData <> "epcoh.csv", epoch];
In[•]:= Export[dirData <> "Lstar.csv", Lstar];
In[•]:= Export[dirData <> "L.csv", L];
In[•]:= Export[dirData <> "I.csv", I];
```

```
In[•]:= Export[dirData <> "Bcalc.csv", Bcalc];

In[•]:= Export[dirData <> "Beq.csv", Beq];

In[•]:= Export[dirData <> "Lratio.csv", L/Lstar];

In[•]:= Export[dirData <> "Bratio.csv", Bcalc/Beq];
```

---

end

```
In[•]:= (* save notebook *)
        NotebookSave[EvaluationNotebook[]];
```