Package 'SCEPtER'

July 2, 2014

Title Stellar CharactEristics Pisa Estimation gRid

Version 0.1-0

Date 2013-06-02

Description A package to estimate stellar mass and radius given observational data of effective temperature, [Fe/H], and astroseismic parameters. The results are obtained adopting a maximum likelihood technique over a grid of computed stellar models.

Suggests lattice

Depends R (>= 2.10), MASS

LazyData yes

License GPL (>= 2)

Maintainer Matteo Dell'Omodarme <mattdell@fastmail.fm>

Author Matteo Dell'Omodarme [aut, cre], Giada Valle [aut]

NeedsCompilation yes

Repository CRAN

Date/Publication 2013-06-04 16:09:42

R topics documented:

SCEPtER-package *A grid-based estimation tool for stellar masses and radii*

Description

The package estimates stellar mass and radius given observational data of effective temperature, [Fe/H], and astroseismic parameters. The results are obtained adopting a maximum likelihood technique on a grid of computed stellar models.

References

G. Valle, M. Dell'Omodarme, P.G. Prada Moroni, and S. Degl'Innocenti (2013). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar CharactEristics Pisa Estimation gRid*. In preparation.

errorObs *Perturbe a set of observational data*

Description

The function returns a perturbed object, starting from observational data and a vector of uncertainties.

Usage

```
errorObs(sigma, STAR)
```

Arguments

sigma	a vector of 5 elements containing the uncertainties on observational data. The error on seismic parameters must be expressed as percentage.
STAR	a vector of 5 elements containing the observational data.

Details

The vector of observations STAR must contain, in the order:

1. The effective temperature (in K) of the star.
2. The logarithm of the surface gravity of the star (in cm s^-2).
3. The metallicity [Fe/H] of the star.
4. The value of large frequency separation of the star, divided by the solar value of this quantity.
5. The value of the frequency of maximum oscillation power of the star, divided by the solar value of this quantity.

The vector of the uncertainties on the observation sigma must contain the uncertainty on the above quantity. The uncertainty on the last two values must be expressed as percentage.

Value

`errorObs` returns an object obtained sampling from a multivariate normal distribution with vector of mean `star` and covariance matrix `diag(sigma^2)`.

`estimateError` *Monte Carlo simulation for a single object*

Description

The function computes the grid-based estimates of the mass and radius for several objects perturbing their observational data with a random uncertainty. It can be used to assess the performance of the recovery procedure sampling from different grids.

Usage

```
estimateError(data, STAR, sigma, thr, sel)
```

Arguments

`data`	the matrix estimation grid.
`STAR`	a matrix of 5 columns, containing by row the observational data of the objects.
`sigma`	a vector of 5 elements, containing the error on observational data. The error on seismic parameters are expressed as percentage.
`thr`	the threshold for the selection of cases over which the computation of likelihood is performed
`sel`	a vector of 5 elements, containing 1 or 0 for inclusion or exclusion of a observational quantity from the likelihood computation.

Value

`estimateError` returns a data frame with the grid-based estimates of stellar parameters for each row in the matrix `STAR`. In the columns of the output object there are:

1. The grid-based estimate of the mass of the star.
2. The grid-based estimate of the radius of the star.
3. The number of points in the sampling grid which concurred in the estimates of mass and radius. For details on the technique, see references below.
4. The true mass of the star.
5. The true radius of the star.
6. The logarithm of the age of the star (in yr).
7. The ratio between the age of the star and the time needed for central hydrogen depletion for that star.
8. The metallicity [Fe/H] of the star.

9. The relative error on the grid-based estimate of the mass.
10. The relative error on the grid-based estimate of the radius.

For each row i in `STAR`, the observational data are perturbed adding a random noise, sampled from a multivariate normal distribution with mean given by the i-th row of `STAR` and covariance matrix `diag(sigma^2)`.

References

G. Valle, M. Dell'Omodarme, P.G. Prada Moroni, and S. Degl'Innocenti (2013). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar CharactEristics Pisa Estimation gRid*. In preparation.

S. Basu, G.A. Verner, W.J. Chaplin, and Y. Elsworth (2012). *Effect of Uncertainties in Stellar Model Parameters on Estimated Masses and Radii of Single Stars*. The Astrophysical Journal, 746, 76.

N. Gai, S. Basu, W.J. Chaplin, and Y. Elsworth (2011). *An In-depth Study of Grid-based Asteroseismic Analysis*. The Astrophysical Journal, 730, 63.

Examples

```
data(stdGrid)

sigma <- c(100, 0.25, 0.1, 0.025, 0.05)
star <- sampleStar(200, stdGrid)

res <- estimateError(stdGrid, star, sigma, 3, c(1, 0, 1, 1, 1))

plot(density(res$errorM))

plot(R ~ trueR, data=res)
```

`estimatePert` *Mass and radius estimates for a single object*

Description

The function computes the grid-based estimates of the mass and radius for one object. A Monte Carlo simulation is performed to estimate the statistical uncertainty on the derived quantities.

Usage

```
estimatePert(data, STAR, sigma, thr, sel, Nrun=10000)
```

Arguments

data	the matrix estimation grid.
STAR	a vector of 5 elements, containing the observational data.
sigma	a vector of 5 elements, containing the error on observational data. The error on seismic parameters are expressed as percentage.
thr	the threshold for the selection of cases over which the computation of likelihood is performed.
sel	a vector of 5 elements, containing 1 or 0 for inclusion or exclusion of a observational data from the likelihood computation.
Nrun	the number of replication in the Monte Carlo simulation.

Value

`estimatePert` returns a data frame obtained with the `Nrun` estimates of stellar parameters. For each simulation, the object to be reconstructed is obtained sampling from a multivariate normal distribution with mean given by `STAR` and covariance matrix `diag(sigma^2)`.

Mass and radius estimates are obtained by a maximum likelihood technique widely adopted in literature. Details on the technique can be found in the references reported below.

References

G. Valle, M. Dell'Omodarme, P.G. Prada Moroni, and S. Degl'Innocenti (2013). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar CharactEristics Pisa Estimation gRid*. In preparation.

S. Basu, G.A. Verner, W.J. Chaplin, and Y. Elsworth (2012). *Effect of Uncertainties in Stellar Model Parameters on Estimated Masses and Radii of Single Stars*. The Astrophysical Journal, 746, 76.

N. Gai, S. Basu, W.J. Chaplin, and Y. Elsworth (2011). *An In-depth Study of Grid-based Asteroseismic Analysis*. The Astrophysical Journal, 730, 63.

Examples

```
# Solar seismic data from  Thiery et al. (2000)
Dnisun <- 134.8
nimaxsun <- 3034

# Observational data for alpha Cent B from:
# Kjeldsen et al. (2005), Porto de Mello et al. (2008)
# Observed mass and radius: 0.935 +- 0.006, 0.863 +- 0.005
# from Miglio & Montalban (2005)
acenB <- c(5316, 0, 0.25, 161.5/Dnisun, 4100/nimaxsun)
sigmaCen <- c(30, 0, 0.04, 0.01, 0.05)

# Load the standard estimation grid
data(stdGrid)

# For accurate estimates adopt at least Nrun=10000
res <- estimatePert(stdGrid, acenB, sigmaCen, 3, c(1,0,1,1,1), Nrun=200)
```

```
quantile(res$M, c(0.16, 0.5, 0.84))
quantile(res$R, c(0.16, 0.5, 0.84))
```

`sampleStar` *Sample a set of objects out of a grid*

Description

The function extracts, without replacement, a sample of objects out of a grid.

Usage

```
sampleStar(n, grid)
```

Arguments

`n`	The number of objects to be sampled.
`grid`	The grid from which the objects are sampled.

Value

`sampleStar` returns a matrix of `n` rows, sampled without replacement from `grid`.

Examples

```
data(stdGrid)
STARS <- sampleStar(10, stdGrid)
```

`stdGrid` *Standard grid for mass and radius estimation*

Description

The standard grid for mass and radius determination through a maximum likelihood technique. The grid is computed assuming the solar scaled mixing-length value.

Usage

```
stdGrid
```

Format

A data frames containing 9 variables:

Teff The effective temperature of the star (in K).

logg The logarithm of the surface gravity of the star (in cm s^-2).

FeH The metallicity [Fe/H] of the star.

Dni The large frequency separation for the star (in unit of solar large frequency separation).

nimax The frequency of maximum oscillation power for the star (in unit of solar frequency of maximum oscillation power).

M The mass of the star (in unit of solar mass).

R The radius of the star (in unit of solar radius)

logAge The logarithm of the age of the star (in yr).

pcAge The ratio between the age of the star and the time needed for central hydrogen depletion for that star.

Source

G. Valle, M. Dell'Omodarme, P.G. Prada Moroni, and S. Degl'Innocenti (2013). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar CharactEristics Pisa Estimation gRid*. In preparation.

Index