

Package ‘SCEPtER’

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Title Stellar CharactEristics Pisa Estimation gRid

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Description SCEPtER pipeline for estimating the stellar age, mass, and radius given observational effective temperature, [Fe/H], and astroseismic parameters. The results are obtained adopting a maximum likelihood technique over a grid of pre-computed stellar models.

Suggests lattice

Depends R (>= 3.1.0), MASS, parallel

LazyData yes

License GPL (>= 2)

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 SCEPtER-package

A grid-based estimation tool for stellar ages, masses, and radii

Description

The package estimates stellar mass, radius, and age 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 (2014). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar Characteristics Pisa Estimation gRid*. A&A, 561, A125.

G. Valle, M. Dell’Omodarme, P.G. Prada Moroni, and S. Degl’Innocenti (2014). *Uncertainties in asteroseismic grid-based estimates of stellar ages. SCEPtER: Stellar Characteristics Pisa Estimation gRid*. A&A, accepted.

 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, parallel=FALSE, corr=0)
```

Arguments

sigma	a vector of 7 elements containing the uncertainties on observational data. The error on seismic parameters must be expressed as percentage.
STAR	a vector of 7 elements containing the observational data.
parallel	logical flag specifying if the computation should be performed in parallel on a multi-core architecture.
corr	the value of assumed the correlation between asteroseismic parameters. Default to zero (no correlation).

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.
6. The mass (in solar units) of the star (if known).
7. The radius (in solar unit) of the star (if known).

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 relative error.

Value

errorObs returns an object obtained sampling from a multivariate normal distribution with vector of mean star and covariance matrix $\text{diag}(\sigma^2)$, with elements (4,5) and (5,4) modified according to the value of corr.

<code>estimate</code>	<i>Mass, radius, and age estimates for the supplied objects</i>
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Description

The function computes the grid-based estimates of the mass, radius, and age for the supplied objects.

Usage

```
estimate(data, STAR, sigma, thr, sel, parallel=FALSE)
```

Arguments

<code>data</code>	the matrix estimation grid. The matrix should be sorted according to the values in the first column (the stellar effective temperature).
<code>STAR</code>	a matrix of 7 columns, containing in each row the observational data of the stellar objects.
<code>sigma</code>	a vector of 7 elements, containing the error on observational data. The error on seismic parameters are expressed as relative error.
<code>thr</code>	the threshold for the selection of cases over which the computation of likelihood is performed.
<code>sel</code>	a vector of 7 elements, containing 1 or 0 for inclusion or exclusion of a observational data from the likelihood computation.
<code>parallel</code>	logical flag indicating if the estimations should be performed in parallel on a multi-core architecture.

Value

STAR should contains in order: the stellar effective temperature, the logarithm of the surface gravity, the metallicity [Fe/H], the average large frequency separation (in micro Hz), the maximum oscillation power (in micro Hz), the mass (in solar units), the radius (in solar units). `sigma` should contain, in the same order, the uncertainties on the observational quantities.

`estimate` returns a data frame obtained with the estimates of stellar parameters for each row of the input matrix STAR. In the columns of the data frame there are: the identifier `id` of the row of the input matrix adopted for the estimate; the mass estimate `M` (in solar units); the radius estimate `R` (in solar units); the age estimate `age` (in Gyr).

Mass, radius, and age 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 (2014). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar CharactEristics Pisa Estimation gRid*. A&A, 561, A125.

G. Valle, M. Dell’Omodarme, P.G. Prada Moroni, and S. Degl’Innocenti (2014). *Uncertainties in asteroseismic grid-based estimates of stellar ages. SCEPtER: Stellar CharactEristics Pisa Estimation gRid*. A&A, accepted.

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 & Montalbán (2005)
acenB <- c(5316, 0, 0.25, 161.5/Dnisun, 4100/nimaxsun, 0.935, 0.863)
sigmaCen <- c(30, 0, 0.04, 0.01, 0.05, 0.006/0.935, 0.005/0.863)

# Load the standard estimation grid
data(stdGrid)

# order standard grid by effective temperature (required by estimate)
ii <- do.call(order, as.data.frame(stdGrid[,1]))
oGrid <- stdGrid[ii, ]

# For accurate estimates adopt at least NUM=10000
NUM <- 200
# obtain NUM copies of the object and add Gaussian perturbations
star <- matrix(acenB, byrow=TRUE, nrow=NUM, ncol=7)
```

```
starp <- errorObs(sigmaCen, star)

# select the observational constraints
# using Teff, [Fe/H], Delta nu, nu_max
vsel <- c(1,0,1,1,1,0,0)

# call the estimation routines
res <- estimate(oGrid, starp, sigmaCen, 3, vsel)

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, restrict=TRUE)
```

Arguments

n	the number of objects to be sampled.
grid	the grid from which the objects are sampled.
restrict	logical flag indicating if only models younger than 14 Gyr should be considered.

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 (2014). *Uncertainties in grid-based estimates of stellar mass and radius. SCEPtER: Stellar Characteristics Pisa Estimation gRid*. A&A, 561, A125.

G. Valle, M. Dell’Omodarme, P.G. Prada Moroni, and S. Degl’Innocenti (2014). *Uncertainties in asteroseismic grid-based estimates of stellar ages. SCEPtER: Stellar Characteristics Pisa Estimation gRid*. A&A, accepted.

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