Inventory of Supporting Information

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| Please complete each of the Inventory Tables below to outline your Extended Data and Supplementary Information items.  There are four sections:   * *Extended Data* * *Supplementary Information: Flat Files* * *Supplementary Information: Additional Files* * *Source Data*   Each section includes specific instructions. Please complete these tables as fully as possible. We ask that you avoid using spaces in your file names, and instead use underscores, i.e.: Smith\_ED\_Fig1.jpg not Smith ED Fig1.jpg  Please note that titles and descriptive captions will only be lightly edited, so please ensure that you are satisfied with these prior to submission.  If you have any questions about any of the information contained in this inventory, please contact the journal. |
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1. **Extended Data**

**Complete the Inventory below for all Extended Data figures.**

* Keep Figure Titles to one sentence only
* Upload your files as ‘Figure Files’ in our Manuscript Tracking system
* File names should include the Figure Number. i.e.: *Smith\_ED\_Fig1.jpg*
* Please be sure to include the file extension in the Filename. Note that Extended Data files must be submitted as .jpg, .tif or .eps files *only*, and should be approximately 10MB
* All Extended Data figure legends must be provided in the Inventory below and should not exceed 300 words each *(if possible)*
* Please include Extended Data *ONLY* in this table

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| Figure # | Figure title  One sentence only | Filename  This should be the name the file is saved as when it is uploaded to our system. Please include the file extension. i.e.: *Smith\_ED\_Fig1.jpg* | Figure Legend  If you are citing a reference for the first time in these legends, please include all new references in the main text Methods References section, and carry on the numbering from the main References section of the paper. If your paper does not have a Methods section, include all new references at the end of the main Reference list. |
| Extended Data Fig. 1 | A probabilistic graphical model (PGM) represented algebraically in Equation 2. | ED\_pgm\_models\_Fig1.jpg | The shaded circle indicates observed data, and solid black points represent other fixed information, such as the KDEs and observational uncertainties. The remaining circles represent parameters. The underline indicates that the symbol represents a set of parameters or data. Here, $\kappa\_{\rm{s}}$ and $\kappa\_{\rm WMB}$ represent the KDEs of standard and WMB model populations respectively. $Q\_{\rm{WMB}}$ is the mixture model weighting factor. The latent parameters $\theta$, our observations $\mathcal{D}$ and their uncertainties $\sigma\_{\mathcal{D}}$ include temperature $T\_{\rm eff}$), mass ($M$), log-age ($\ln(t)$), metallicity $\rm{[Fe/H]}$) and log-rotation ($\ln(P)$). This model is \textit{hierarchical}, as all the latent parameters are drawn from the common probability distribution set by $Q\_{\rm{WMB}}$ and described in Equation \ref{eq:mixturell}. |

***Delete rows as needed to accommodate the number of figures (10 is the maximum allowed).***

1. **Supplementary Information:**
2. **Flat Files**

**Complete the Inventory below for all additional textual information and any additional Supplementary Figures, which should be supplied in one combined PDF file.**

* **Row 1:** A combined, flat PDF containing any Supplementary Text, Discussion, Notes, Additional Supplementary Figures, Supplementary Protocols, simple tables, and all associated legends. Only one such file is permitted.
* **Row 2:** Nature Research’s Reporting Summary; if previously requested by the editor, please provide an updated Summary, fully completed, without any mark-ups or comments. **(Reporting Summaries are not required for all manuscripts.)**

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| Item | Present? | Filename  This should be the name the file is saved as when it is uploaded to our system, and should include the file extension. The extension must be .pdf | A brief, numerical description of file contents.  i.e.: *Supplementary Figures 1-4, Supplementary Discussion, and Supplementary Tables 1-4.* |
| Supplementary Information | Yes | supplementary\_information.pdf | Sections: Asteroseismic Model, Verifying asteroseismic results, Verifying consequences for gyrochronology. Figures: Supplementary Figures 1-5. Tables: Supplementary Table 1. |
| Reporting Summary | Choose an item. |  |

1. **Additional Supplementary Files**

**Complete the Inventory below for all additional Supplementary Files that cannot be submitted as part of the Combined PDF.**

* Do not list Supplementary Figures in this table (see section 2A)
* Where possible, include the title and description within the file itself
* Spreadsheet-based tables & data should be combined into a workbook with multiple tabs, not submitted as individual files.
* Compressed files are acceptable where necessary. ZIP files are preferred.
* Please note that the *ONLY* allowable types of additional Supplementary Files are:

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| * Supplementary Tables | * Supplementary Audio | * Supplementary Videos | * Supplementary Software |
| * Supplementary Data, for example: raw NMR Data, Cryo-EM Data, Computational Data, Crystallographic Data, etc. | | | |

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| Type | Number  If there are multiple files of the same type this should be the numerical indicator. i.e. “1” for Video 1, “2” for Video 2, etc. | Filename  This should be the name the file is saved as when it is uploaded to our system, and should include the file extension. i.e.: *Smith\_ Supplementary\_Video\_1.mov* | Legend or Descriptive Caption  Describe the contents of the file |
| Supplementary Table | 1 | SItable1.csv | A .csv file with the contents of Supplementary Table 1, included in the Supplementary Information .pdf file. |

***Add rows as needed to accommodate the number of files.***

1. **Source Data**

**Complete the Inventory below for all Source Data files.**

* Acceptable types of Source Data for Main Figures and Extended Data Figures are:
  + Statistical Source Data
    - Plain Text (ASCII, TXT) or Excel formats only
    - One file for each relevant Figure, containing all source data
  + Full-length, unprocessed Gels or Blots
    - JPG, TIF, or PDF formats only
    - One file for each relevant Figure, containing all supporting blots and/or gels
* ‘Source Data’ is only allowed for Main Figures and Extended Data Figures.
  + Include Unprocessed Gels or Blots for Supplementary Figures as additional Supplementary Figures.
  + Include Statistical Source Data for Supplementary Figures as ‘Supplementary Data’ files and list them in section 2B.
  + Please see [this example of Source Data](https://www.nature.com/articles/s41591-019-0505-4) in a publication.

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| Parent Figure or Table | Filename  This should be the name the file is saved as when it is uploaded to our system, and should include the file extension. i.e.: *Smith\_SourceData\_Fig1.xls,* or *Smith\_ Unmodified\_Gels\_Fig1.pdf* | Data description  i.e.: Unprocessed Western Blots and/or gels, Statistical Source Data, etc. |
| Source Data Fig. 1 | data\_Fig1.pdf | Stellar sample on Kiel diagram. |
| Source Data Fig. 2 | surf-seis-comparison\_update\_Fig2.pdf | Surface vs seismic rotation rates |
| Source Data Fig. 3 | fullsample\_Fig3.pdf | Rotation results overlaid on stellar models. |
| Source Data Fig. 4 | modelresults\_Fig4.pdf | Posterior probabilities of Q\_WMB |
| Source Data Extended Data Fig. 1 | ED\_pgm\_models\_Fig1.jpg | Probabilistic Graphical Model |