The Belgian Repository of fundamental Atomic data and Stellar Spectra

Mike Laverick    Alex Lobel    Pierre Royer    Christophe Martayan
Thibault Merle    Mathieu Van der Swaelmen    Peter van Hoof

University of Leuven, Belgium
Royal Observatory of Belgium, Brussels
European Southern Observatory, Chile
Université Libre de Bruxelles, Belgium
Science motivation

• First steps towards removing systematic errors from input atomic data in stellar spectroscopy

• Compilation of high-quality optical spectral atlases of bright benchmark BAFGK stars with confirmed line identifications and quality-tested atomic data.

• Perform detailed spectral synthesis calculations to test quality of atomic line input data from literature and online data providers (VALD/NIST/etc) by modeling bright benchmark stars.

• Provide observed and theoretical spectra combined with quality-tested atomic data in a new public online database called BRASS
Science motivation: previous literature work
Science motivation: benchmark spectra

- ~30 spectra of bright BAFGK stars with S/N ratio ~1000, taken using the Mercator-HERMES and VLT-UVES high-resolution spectrographs.
Science motivation: high-quality spectra

- Over 1000 spectra of BAFGK stars with good stellar parameter-space coverage. S/N ratios of ~100-300+ and taken with Mercator-HERMES.
Science motivation: synthesis & line identification

- Detailed spectral calculations of entire benchmark spectra (inc. molecules)

Lobel et al. 2017
Science motivation: quality-assessed atomic data

- Benchmark spectra quality high enough to compare and assess literature atomic data on the largest scale to date (\(\lambda\), spectral type, quantity)

- Scatter in atomic data can have significant impact on stellar parameters

![Graph showing spectral lines comparison between BRASS, NIST, and VALD datasets for Fe I 4799.406 Å transition.](image)
Science motivation: BRASS database (brass.sdf.org)
Where do I fit in to BRASS?

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Atomic lines

Laverick et al: BRASS I. Cross-matching atomic databases of astrophysical interest

Table 4. (a) - (c) show three sets of cross-matched lines. (a) the Mn II pair have been correctly cross-matched by both the parametric and non-parametric methods. (b) the Cr I pair have been incorrectly cross-matched using the parametric method and not the non-parametric method. (c) the Fe II pair have been incorrectly cross-matched using the parametric method and not the non-parametric method.

<table>
<thead>
<tr>
<th>Ion</th>
<th>( \lambda ) (Å)</th>
<th>( E_{\text{low}} ) (eV)</th>
<th>( E_{\text{up}} ) (eV)</th>
<th>( J_{\text{low}} )</th>
<th>( J_{\text{up}} )</th>
<th>Configuration: lower - upper</th>
<th>references</th>
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<tbody>
<tr>
<td>(a)</td>
<td>Mn II</td>
<td>4639.152</td>
<td>10.774</td>
<td>13.446</td>
<td>3</td>
<td>2</td>
<td>3d^4(^5D)4s4p(^3P^o) w^5P^o - 3d^5(^6S)7s^5S</td>
</tr>
<tr>
<td></td>
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<td>10.774</td>
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</tr>
<tr>
<td>(b)^*</td>
<td>Cr I</td>
<td>4244.770</td>
<td>3.890</td>
<td>6.810</td>
<td>4</td>
<td>5</td>
<td>3d^4(^4F)4s a^5F - 3d^5(^4G)5p v^3H^o</td>
</tr>
<tr>
<td></td>
<td>Cr I</td>
<td>4244.340</td>
<td>3.857</td>
<td>6.777</td>
<td>4</td>
<td>5</td>
<td>3d^4(^5D)4s4p(^3P^o) z^5F^o - e^5F</td>
</tr>
<tr>
<td>(c)^**</td>
<td>Fe II</td>
<td>6207.273</td>
<td>11.051</td>
<td>13.048</td>
<td>7/2</td>
<td>5/2</td>
<td>3d^6(^5D)5p 6P^e - 3d^6(^5D)5d 6S</td>
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</tr>
</tbody>
</table>

Notes. *Cross-matched using \( \Delta E = \pm 0.1 \) eV **Cross-matched using \( \Delta E = \pm 0.0005 \) eV ^aKurucz 1999-2014 ^bKramida & Sansonetti 2013 ^cSaloman 2012 ^dRaassen & Uylings 1998

• Several line lists and repositories cross-matched against our BRASS atomic line list (including VALD3, NIST, SpectroWeb, Chianti, TIP/TOPbase)

• ~130,000 transitions cross-matched with our BRASS list of 80,000 lines
Atomic lines: (available at brass.sdf.org)

- Cross-matched atomic data available via the brass.sdf.org → “lines” Tab (currently under development)
Updates to literature log(gf) values over time. Scatter up to 2 dex!
Atomic lines: BRASS vs NIST (2012 vs 2016)

- Scatter still up to 2 dex!
Atomic lines: BRASS vs SpectroWeb (2012 vs 2008)

- Scatter up to 4 dex for older transitions!

Laverick et al 2017 (Submitted)
Atomic lines: BRASS vs TOPbase (2012 vs 1993)

- Changes in log(gf) values lead to similar changes in line abundances !!!

Laverick et al 2017 (Submitted)
Atomic lines: line selection

- Systematic selection of deep + unblended lines using our 80,000 lines, performed for each BAFGK spectral type

- Synthesise each line individually - line considered “unblended” if it reproduces at least 90% of the total synthetic line profile
Atomic lines: line selection

- G type stars: ~1500 theoretically deep and unblended lines to assess

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Element: Neutral and Ionic lines

- Neutral
- Ionic
Atomic lines: quality assessment

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- Theoretical Curve of Growth

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5) Good fits means line can be assessed. Bad fits are likely hidden blends
Atomic lines: quality assessment results

Sun

Normalized flux

Wavelength [Å]

Fe I 5619.59540

<table>
<thead>
<tr>
<th>Source</th>
<th>λ [Å]</th>
<th>log(gf)</th>
<th>Δlog(gf)</th>
<th>χ²(λcorr)</th>
<th>W_eq [mÅ]</th>
<th>Nor. depth</th>
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<tbody>
<tr>
<td>Observed</td>
<td>5619.5938</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>G–benchmarks</td>
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<td>0.0166</td>
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<td>0.30463</td>
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<td>0.0279</td>
<td>31.2</td>
<td>0.27674</td>
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<tr>
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<td>0.0336</td>
<td>28.3</td>
<td>0.25212</td>
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<tr>
<td>SpectroWeb</td>
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<td>0.0434</td>
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<tr>
<td>VALD</td>
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<td>-1.7</td>
<td>0.169</td>
<td>0.0431</td>
<td>24.6</td>
<td>0.21849</td>
</tr>
</tbody>
</table>
BRASS: Results and future work
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- Preliminary results available online at brass.sdf.org
- Quality assessment for ~700 G-type atomic lines
- Publication of complete g-type results by the end of the year
BRASS: Results and future work

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- Quality assessment for ~700 G-type atomic lines
- Publication of complete g-type results by the end of the year
- Expand quality assessment work to B,A,F,K spectral types
- Complete spectral processing work of over 1000 different targets
- Fully release the BRASS database including all data products
Thank you for listening!

Questions?