# Benchmarking Visible Spectral Line Data for Highly Charged Tungsten Using an EBIT and GRASP Calculations.

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In this contribution we will discuss a single spectral line in $W^{27+}$ - an M1 line between the two ground state fine structure levels $4d^{10}4f\ ^2F_{7/2}$ and $^2F_{5/2}$. This is the only transition within the ground configuration of this ion and therefore a challenge to identify spectroscopically. We have studied this line both experimentally using an EBIT and theoretically using the GRASP2K code [1]. These investigations were done independently and the results only compared when both methods had reached a conclusive wavelength, from careful and systematic considerations. One of the motivation for this work was the fact that earlier predictions for this transition showed a spread of over 400 Å for the wavelength [2, 3]. Our experiments were performed using the Shanghai permanent magnet EBIT and an Andor 303 Shamrock spectrometer equipped with an Andor Newton CCD camera. Tungsten was injected into the EBIT using the vaporous compound $W(CO)_6$. Spectra were recorded at several electron beam energies to isolate the $W^{27+}$ line. The spectra were wavelength calibrated using a number of calibration lamps and the final experimental wavelength was determined to be 3377.43 ± 0.26 Å. To confirm the line was really from $W^{27+}$ we determined the lifetime of the upper level of the $^2F$ term and compared our value with one from a calculation. As the line is from an M1 transition the lifetime of the upper level it is trivial to calculate the rate and thereby the lifetime. Our theoretical studies are systematic in two senses – first we investigate the contributions to the wavelength from different core subshells. These studies implies it is important to include core valence correlation even between the valence 4f and deep subshells – as a matter of fact, the correlation contribution from 3d is more pronounced than from 4d. The second dimension of the systematic approach is an increase of the *active set* of orbitals, and thereby the *space of configuration state functions (CSFs)* to show convergence of the final results.

Finally, after these independent investigation we are able to do *single-line spectroscopy* to identify this transition, since the agreement between our experimental and theoretical wavelength is within the order 0.1%, since the experimental vacuum wavelength is 3378.43 Å whereas the calculated wavelength is 3374.73 Å. This is probably the best agreement for such a transition in the visible region for a highly charged high Z ion.

We will also discuss cases in which this agreement could be even better, allowing for rigorous tests of minute effects – in the realm of Breit and QED interactions.

[1] Jönsson et al. (2013) Comput. Phys. Commun. **184** 2197

[2] Fei et al. (2012) Phys. Rev. A **86** 062501

[3] Grumer et al. (2014) Phys. Rev. A **89** 062511

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