Identifications of EUV transitions in promethium-like Pt, Ir, Os, and Re

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Recent proposals to use highly charged ions (HCI) in next generation frequency standards, and for measurements of the variation of constants [1,2], has increased the need to understand the electronic structure of these ions. Specifically HCI near level crossings are of high interest, because they feature electric dipole transitions in the extreme ultra-violet (EUV) and optical regime, suitable for precision laser spectroscopy.

The existence of strong $5s - 5p$ EUV transitions in promethium(Pm)-like systems, which are near the $4f - 4s$ level crossing, was already predicted by Curtis and Ellis in 1980 [3]. Experimental observation of these transitions was never definitively confirmed due to the complexity of the spectra and deviations at the 1 %-level from atomic theory predictions.

We have experimentally investigated Pm-like Pt, Ir, Os, and Re ions to gain a better understanding of the electronic structure of these HCI [4]. The ions were produced and stored in an electron beam ion trap (EBIT) where the ions were excited through electron impact, the EUV fluorescence spectra were obtained using a grazing incidence flat-field spectrometer. The near mono-energetic electron beam of the EBIT ensured a well-defined charge state distribution, so that emission lines from different charge states could be separated. The resulting spectra were compared to synthetic spectra which were obtained using a collisional radiative model.

In this manner a number of characteristic transitions could be identified, and their wavelengths could be determined at the 50 ppm level. Even some of the $5s - 5p$ transitions, which appeared very weak in both observed and synthetic spectra, could be identified. Comparison to several state of the art calculations still shows deviations of up to 1 %, signaling the need for alternative, or new techniques in calculating the electronic structure of these complex HCI.

References

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