Identifications of optical transitions in Ir^{17+} for investigations of variations of fundamental constants

A. Windberger[1], O. O. Versolato[2], H. Bekker[1], P. O. Schmidt[2, 3], J. Ullrich[2], and J. R. Crespo López-Urrutia[1]

[1] *Max-Planck-Institut für Kernphysik, Heidelberg, Germany*
[2] *Physikalisch-Technische Bundesanstalt, Braunschweig, Germany*
[3] *Institut für Quantenoptik, Leibniz Universität, Hannover, Germany*

Presenting Author: bekker@mpi-hd.mpg.de

Optical transitions in various highly charged ions (HCI) haven been proposed for the investigation of a possible variation of fundamental constants, and for use in next generation frequency standards [1-3]. The atypical abundance of optical transitions in these HCI is due to a near degeneracy of electronic configurations near a level crossing. Enhanced relativistic effects make Nd-like Ir^{17+}, which is near the $4f - 4s$ level crossing, highly sensitive to variations of the fine-structure constant α. Calculations for the electronic structure of Ir^{17+} are difficult and not accurate enough for precision laser spectroscopy, due to the complex correlations between the electrons in the open $4f$-shell. To resolve this issue, we measured a number of optical transitions in Ir^{17+} with a precision of up to 1 ppm [4].

The ions were produced and stored in an electron beam ion trap (EBIT), where the ions were excited by electron impact. The subsequent emission light was observed using a Czerny-Turner type spectrometer. The Zeeman splitting, caused by the 8.00 T field in the EBIT, could be resolved and exploited to identify a number of magnetic dipole transitions. To further our understanding of Ir^{17+} we investigated Nd-like W^{14+}, Re^{15+}, Os^{16+}, and Pt^{18+} in a similar manner. The identified transitions followed the predicted dependence on the atomic numbers, thereby confirming our identifications. By extrapolating the found scaling we were able to infer the wavelengths of proposed frequency standards in Hf^{12+} and W^{14+} [3].

In the measured Ir^{17+} transitions a search for closed optical cycles (Ritz combinations) was made. This resulted in two mutually exclusive candidates for the sought after transitions with highest sensitivity to α-variation. Recently performed improved measurements of these lines should establish which of the found cycles is correct, and thereby determine the energy splitting between the involved configurations.

References

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