

Trapped ions and X-rays for fundamental studies

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X-ray laser spectroscopy (XRLS) has been demonstrated by using an electron beam ion trap (EBIT) at the recently commissioned free-electron laser Linac Coherent Light Source (LCLS) at SLAC [1]. Many of the limitations in accuracy and selectivity which had hitherto hampered spectroscopic investigations of highly charged ions (HCIs) are overcome by the introduction of XRLS. The present results on $\text{Fe}^{15+,16+}$ strongly challenge state-of-the-art calculations widely used for astrophysical plasma diagnostics. The novel method has also been applied to high-energy synchrotron radiation sources (BESSY II, PETRA III) for studies of the photoionization and excitation of HCIs in charge states as high as Fe^{24+} and at photon energies in the 6 keV range. Future improvements of these X-ray sources, e. g. through radiation seeding, will help to develop this field further. New possibilities appear for the study of astrophysical and terrestrial plasmas as well as for X-ray metrology. The new data stringently benchmark atomic structure theory. By moving into the X-ray region, the study of parity nonconservation and nuclear size effects can benefit from the increased sensitivity of inner-shell electrons to those fundamental effects, in particular in combination with laser polarization of trapped HCIs [2] and sympathetic cooling [3].

[1] S. Bernitt, G. V. Brown, J. K. Rudolph, R. Steinbrügge, A. Graf, M. Leutenegger, S. W. Epp, S. Eberle, K. Kubiček, V. Mäkel, M. C. Simon, E. Träbert, E. W. Magee, C. Beilmann, N. Hell, S. Schippers, A. Müller, S. M. Kahn, A. Surzhykov, Z. Harman, C. H. Keitel, J. Clementson, F. S. Porter, W. Schlotter, J. J. Turner, J. Ullrich, P. Beiersdorfer, J. R. Crespo López-Urrutia, “*An unexpectedly low oscillator strength as the origin of the Fe XVII emission problem*”, *Nature*, accepted (2012)

[2] V. Mäkel, R. Klawitter, G. Brenner, J. R. Crespo López-Urrutia, and J. Ullrich, “*Laser spectroscopy on forbidden transitions in trapped highly charged Ar^{13+} ions*”, *Phys. Rev. Lett.* **107**, 143002 (2011)

[3] M. Schwarz, O. O. Versolato, A. Windberger, F. R. Brunner, T. Ballance, S. N. Eberle, J. Ullrich, P. O. Schmidt, A. K. Hansen, A. D. Gingell, M. Drewsen, and J. R. Crespo López-Urrutia, “*Cryogenic linear Paul trap for cold highly charged ion experiments*”, *Rev. Sci. Instrum.* **83**, 083115 (2012)