Structure and Dynamics of Highly-charged Ions: Physics at Extreme Fields

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Highly charged ions (HCI) combine extremely strong electromagnetic fields and a simple electronic structure, which makes them ideal testing grounds for fundamental theories such as quantum mechanics, relativity and quantum electrodynamics (QED) in the domain of strongest electromagnetic fields available for experimental investigation. In the heaviest few-electron ions, such as hydrogen-like uranium, the field strength exposed on the electron in the ground-state is already very close to the Schwinger limit; the field strength in which a spontaneous electron-positron pair creation can occur. Therefore, the structure of highly-charged ions is strongly influenced by the effects of the quantum vacuum. Furthermore, in stellar plasmas which constitute large part of the visible matter in the universe, high temperatures, high atomic charge-states and high field strengths prevail. Therefore, the investigation of these extreme atomic conditions is very important for our understanding of processes ongoing in astrophysical, but also in laboratory plasmas. In this presentation, an overview of the field of physics with HCI will be given. Emphasis will be put on modern experiments at storage rings, at HCI sources and high precision detection techniques needed to explore this field.