SES16-2016-000197

Abstract for an Invited Paper
for the SES16 Meeting of
the American Physical Society

The World's Smallest Extreme Laboratories: Probing QED with Highly Charged Ions.

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Highly charged ions (HCIs) are atoms in which all or most of the electrons have been stripped off. The remaining few (or one) electrons exist in the presence of the strong electric field generated from the nucleus. In the case of fully stripped Uranium this field is 10^{16} V cm^{-1}, orders of magnitude stronger than any external field available in a laboratory. These ultra strong fields make HCIs ideal mini laboratories in which to test physical theories in extreme conditions. Quantum Electrodynamics (QED) is an extremely powerful and predictive theory describing the interaction of matter and light. However, in the instances where experimental and theoretical results differ there is an opportunity to study non-standard model physics. HCIs are also promising candidates for next generation atomic clocks and searches for time variation in the fundamental "constants". Additionally, while HCIs are rare on Earth, they are commonplace in the universe, in particularly in the high temperature and pressure environments of stars and solar winds. Understanding how to read the photon signature from interactions of HCIs with neutral gases in the universe gives information on the density, temperature and constituents of both.