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Probing Extreme Atomic Physics of Warm and Superdense Plasmas

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Warm and superdense plasmas, having mass density ranging from ~10 to 10^6 g/cm^3 and temperature of 10^4 to 10^7 K, widely exist in the universe (e.g., in planetary cores, and brown and white dwarfs). How atoms (the basic building blocks of matter) behave in such extreme plasma conditions is still largely unknown because of the difficulty creating such extreme environments in laboratories. Thanks to technological advances in both energetic lasers and pulsed-power machines over the past two decades, warm and superdense plasmas can now be accessed by several experimental facilities worldwide. We have combined both first-principles computational tools (e.g., density functional theory) and time-resolved spectroscopy in experiments to probe warm and superdense plasmas. This talk will review the recent progress on the new physics phenomena revealed from in such theory–experiment combined studies, such as the competition of continuum lowering with Fermi surface rising [1], the dipole selection rule breaking and interspecies radiative transitions [2], as well as unusual K-alpha and K-beta emission/absorption features [3] in superdense plasmas.

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[1] S. X. Hu, Phys. Rev. Lett. **119**, 065001 (2017).
[2] S. X. Hu *et al.*, Nat. Commun. **11**, 1989 (2020).
[3] S. X. Hu *et al.*, "Extreme Atomic Physics at Peta-Pascals Probed by Time-Resolved Spectroscopy," to be submitted to Nature Physics.