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Web Seminar

Statistical properties of electromagnetic emission lines from many-electron atoms and heavy nuclei

Keisuke Fujii

Kyoto University, Kyoto, Japan

It has long been observed that the number of weak lines from many-electron atoms follows a power law distribution of intensity [1]. While computer simulations have reproduced this dependence, its origin has not yet been clarified [2]. Here we report that the combination of two statistical models —an exponential increase in the level density of many-electron atoms and local thermal equilibrium of the excited state population— produces a surprisingly simple analytical explanation for this power law dependence [3]. We find that the exponent of the power law is proportional to the electron temperature. This dependence may provide a useful diagnostic tool to extract the temperature of plasmas of complex atoms without the need to assign lines.

We also show that the above discussion is applicable to another fermionic many-body system, heavy nuclei, although its typical energy scale of nuclei is different from that of atoms six orders of magnitude. This is confirmed from 69 datasets contained in National Nuclear Data Center database, regardless of the reaction type or nuclei involved [4]. We discuss the connection between this general property of fermionic many-body systems and other power-laws found in wide variety of science fields.

[1] R. C. M. Learner, *J. Phys. B*, **15**, L891 (1982)
[2] J. Bauche, C. Bauche-Arnoult, and O. Peyrusse, *Atomic Properties in Hot Plasmas* (Springer International Publishing, Cham, 2015).
[3] K. Fujii and J. C. Berengut, *Phy. Rev. Lett.*, **124**, 185002 (2020)
[4] K. Fujii and J. C. Berengut, https://arxiv.org/abs/2005.11844