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Simple explanation for the observed power law distribution of line intensity in complex many-electron atoms and heavy nuclei

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It has long been observed that the number of weak lines from many-electron atoms follows a power law distribution of intensity. While computer simulations have reproduced this dependence, its origin has not yet been clarified. 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. 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.
Because of the generality of this statistical model, a similar principle may apply to other quantum complex system. Indeed, we find for the first time that the gamma-ray emission from heavy nuclei also satisfy a similar power-law intensity distribution. For the nuclei, the power-law exponent is always unity and the intensity parameter of the distribution is independent from nuclear property. We confirm these properties from the experimental results registered in a nuclear database.

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