A Resolution of the Long-Standing X-Ray Puzzle of Astrophysically Relevant Highly Charged Ions

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A long-standing problem of the controversial 3C and 3D astrophysically relevant X-ray lines in neon-like Fe^{16+} ions is discussed. A discrepancy in the intensity ratio I_{3C}/I_{3D} repeatedly raised questions on the accuracy of atomic structure calculations. The disagreement was put in the focus after the first accurate X-ray free-electron laser measurements [1] of these controversial lines.

While the accuracy of theoretical predictions continued improving with the of more and more higher-order electron-correlation effects and with the calculation of quantum electrodynamic effects, all theoretical predictions converged to one value, but the disagreement remained. A possible resolution has been suggested by considering dynamical effects for strong X-ray sources, concluding that the modeling of the spectral lines by a peak with an area proportional to the oscillator strength is not sufficient [2, 3]. An alternative explanation was based on the charge-state population transfer [4].

Renewed experimental efforts with a synchrotron-radiation-based technique [5] brought much better resolution than the LCLS data and excluded population transfer and non-linearities, delievered improved experimental result, and no resolution of the puzzle. Finally, the most recent improvements in the experimental observations and theoretical calculations showed the long-waited mutual agreement [6].

In this talk, the history of this one of the most enduring and intensively studied problems of X-ray astronomy will be discussed. We will focus on theoretical predictions based on the atomic-structure calculation and on the alternative solutions of the riddle. A step-by-step improvement in the experimental technique with a constantly increased accuracy will be analyzed. Finally, we discuss how the further reduction of experimental uncertainties can offer a unique opportunity to benchmark quantum electrodynamic effects for both energies and natural linewidths in a complicated atomic system with 10 electrons.

References

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