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Superradiance and Subradiance in Astrophysics: Rethinking Light-Matter Interactions

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Astrophysical radiative transfer models typically assume that atoms and molecules emit and absorb radiation independently. However, recent evidence suggests that cooperative quantum effects—such as superradiance and potentially subradiance—can significantly alter radiative behavior.

Superradiance, a cooperative quantum emission process, has been observed in star-forming regions, where it coexists with maser activity and challenges traditional density estimates based on spectral lines. I will present observational evidence and discuss its astrophysical implications.

Additionally, subradiance-where radiation is reduced due to quantum interference-has been theoretically predicted in astrophysics and may also influence absorption processes in certain environments. While direct observational evidence is yet to be established, subradiance could provide insights into anomalous densities and deviations from classical radiative transfer models.

By moving beyond traditional assumptions, we can gain a deeper understanding of light-matter interactions, quantum coherence, and the limitations of standard radiative models in space.

Keyword-1

Superradiance

Keyword-2

Subradiance

Keyword-3

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