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Copper-hydrogen collisions and implications on the Galactic evolution of copper

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The astrophysical production sites of copper and its Galactic chemical evolution remain poorly understood. Reliable copper abundances in metal-poor stellar atmospheres can provide vital clues, but these measurements are prone to modeling uncertainties due to departures from local thermodynamic equilibrium (LTE). One of the largest sources of uncertainty in non-LTE modeling of copper arises from the cross-sections for inelastic collisions with hydrogen. To address this, we present new calculations for inelastic collisions between copper and hydrogen, using a combined Linear Combination of Atomic Orbitals (LCAO) and free electron model approach, which provides improved and extended rate coefficients for non-LTE models.

By applying non-LTE corrections to LTE copper abundances in stars from the literature, we find significant changes in the [Cu/Fe] trends. Our results reduce scatter in star-to-star and line-to-line abundances and resolve previous discrepancies between dwarfs and giants. Notably, we identify, for the first time, a potential upturn in [Cu/Fe] at low metallicity and a dip around [Fe/H] = -1.7, which may hint at a Pair Instability Supernova (PISN) signature. These findings shed new light on copper's cosmic origins and highlight its potential as a tracer of nucleosynthesis in the early Galaxy.

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