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Simple self-consistent prediction methods for the phase space of dark matter: from galactic dynamics to phenomenology

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In the context of dark matter (DM) searches, it is crucial to quantify and reduce theoretical uncertainties affecting predictions of observables that depend on the DM velocity distribution, including event rates in direct searches, velocity-dependent annihilation rates, and microlensing event rates for DM compact objects. The well-known Eddington inversion formalism for the self- consistent reconstruction of the isotropic DM phase-space distribution from a galactic mass model allows one to go beyond the simplistic Maxwell-Boltzmann approximation or direct extrapolations from cosmological simulations, with limited technicalities. However, this method and its anisotropic extensions can be ill-defined depending on the DM and baryonic content of the galaxy of interest. In this presentation, I will first discuss the validity range of the Eddington inversion methods from a theoretical perspective, as well as issues relevant to DM searches. Then, even in their theoretical validity range, these methods must be tested against hydrodynamical cosmological simulations to assess their relevance for complex gravitational systems such as Milky-Way-like galaxies. I will therefore discuss the predictivity of these methods based on zoom simulations. As an application, I will also present novel constraints on p-wave suppressed DM annihilation from positron data, and their associated theoretical uncertainties.

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