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The cosmic rate of pair-instability supernovae

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Pair-instability supernovae (PISNe) are explosions developing in the core of massive stars due to a thermonuclear, runaway process, ultimately leading to the total disruption of the progenitor.
They are expected to be the endpoint of the evolution of low-metallicity stars in the mass range between ~ 140 and 260 solar masses, and responsible for the existence of the upper mass gap in the black hole mass spectrum.
Despite the robust theoretical understanding of the pair-production mechanism, and their crucial implications for many astrophysical observations, PISNe have never been confidently observed. However, they are expected to be up to two orders of magnitude more luminous than typical core-collapse supernovae (CCSNe), for which we have hundreds of observations. This leads to naturally wonder what could be the reason of their missed detection.

In this talk, I will present new results on the PISN rate as a function of redshift, obtained by combining up-to-date stellar evolution tracks from the PARSEC code, implemented in the population synthesis code SEVN, with an up-to-date empirical determination of the galaxy star formation rate and metallicity evolution throughout cosmic history. The goal is to provide a robust theoretical framework to understand where PISNe are across cosmic time, and study their detectability with instruments like JWST.
I will show how the PISN rate is affected by various assumptions in the theoretical models, including the criterion adopted to identify stars unstable against pair production, the maximum stellar metallicity to have PISNe, the upper limit of the stellar initial mass function, and the dispersion of the galaxy metallicity distribution in redshift.
Finally, I will discuss the expected PISN rate contribution coming from isolated binary evolution and star clusters, and how possible (or lack of) future PISN observations can help us constrain stellar and galaxy evolution models.

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