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Probing the nature of Dark Matter with the first stars and galaxies in the Universe

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Launched at the end of 2021, the James Webb Space Telescope (JWST) has already begun to revolutionize our view of the cosmic dawn era. Specifically, it discovered an unexpectedly large number of extremely bright objects in the sky from the early Universe, whose light was emitted more than thirteen billion years ago. If these objects are interpreted as some of the first galaxies ever assembled, their discovery would be in stark contrast with the expectation set by numerical simulations, which predicted such bright galaxies to have formed significantly later. For this reason, those JWST objects are sometimes mistakenly called "cosmology breakers." In fact, in view of HST data, which highly disfavors a cosmological solution to this problem, it would be more appropriate to call them "astrophysics benders." In addition, a combination of IR and X-ray data data further strengthen another problem in astrophysics: the origin of the supermassive black holes that power the large number of very bright quasars observed when the Universe was younger than 900 Myrs. Combined, those two problems indicate that the current understanding of the formation of the first stars and galaxies is, at best, incomplete. However, this "understanding" is largely based on theoretical and numerical models that ignore the role Dark Matter can play on the formation of the first stars. In 2008 Spolyar, Freese, and Gondolo [Phys. Rev. Lett. 100, 051101] have shown that the heat due to the annihilation of Weakly Interactive Massive Particles (WIMPs) at the center of high redshift Dark Matter halos can halt the collapse of zero metallicity protostellar gas clouds. In other words, a new kind of star can form, powered exclusively by Dark Matter annihilations. In view of their power source, those objects are called Dark Stars, although, they can be as bright as a galaxy and grow as massive as a million Suns. In this talk I will review the theoretical and observational status of Dark Stars and show how they can be natural solutions to both of the puzzles described above. Specifically, I will demonstrate how Dark Stars can provide natural massive Black Hole seeds needed to explain the most distant quasars ever observed, such as UHZ1. I will also discuss the three Supermassive Dark Star candidates already identified with JWST (JADES-GS-z-13, JADES-GS-z12, and JADES-GS-z-11) [PNAS 120 (30)] and prospects for spectroscopic confirmation of Dark Stars. The unambiguous detection of any such object, via any of its spectroscopic smoking gun signatures (such as the HeII1640 absorption) would imply the first non-gravitational confirmation of the existence of Dark Matter.

Autore principale: ILIE, Cosmin (Colgate University)

Coautore: PAULIN, Jillian (University of Pennsylvania); FREESE, Katherine (University of Texas at Austin)

Relatore: ILIE, Cosmin (Colgate University)

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