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Detectability of Supermassive Dark Stars with the Roman Space Telescope

Monday, 8 July 2024 18:00 (30 minutes)

Supermassive dark stars (SMDS) are luminous stellar objects formed in the early Universe at redshift $z \sim 10 - 20$, made primarily of hydrogen and helium, yet powered by dark matter.
We examine the capabilities of the Roman Space Telescope (RST), and find it able to identify $\sim 10^6 M_\odot$ SMDSs at redshifts up to $z \sim 14$. With a gravitational lensing factor of $\mu \sim 100$, RST could identify SMDS as small as $\sim 10^4 M_\odot$ at $z \sim 12$ with $\sim 10^6$s exposure.
Differentiating SMDSs from early galaxies containing zero metallicity stars at similar redshifts requires spectral, photometric, and morphological comparisons. With only RST, differentiation of SMDS, particularly those formed via adiabatic contraction with $M \geq 10^5 M_\odot$ and lensed by $\mu \geq 100$, is possible due to their distinct photometric signatures from the first galaxies. Those formed via dark matter capture can be differentiated only by image morphology: i.e. point object (SMDSs) vs. extended object (sufficiently magnified galaxies).
By additionally employing James Webb Space Telescope (JWST) spectroscopy, we can identify the HeII λ1640 absorption line, a "smoking gun" for SMDS detection. Although RST doesn't cover the required wavelength band (for $z_{\rm emi} \geq 10$), JWST does, hence the two can be used in tandem to identify SMDS.
The detection of SMDS would confirm a new type of star powered by dark matter and may shed light on the origins of the supermassive black holes powering bright quasars observed at $z \geq 6$.

Primary author: ZHANG, Saiyang

Co-authors: FREESE, Katherine (University of Texas- Austin); ILIE, cosmin

Presenter: ZHANG, Saiyang

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