

# CASPEN Report

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Report on CASPEN visit to KIPAC at SLAC

Dates: 27 January – 10 February 2024

Host: Rebecca Leane (KIPAC, SLAC)

## 1 Scientific background and purpose of visit

Dark matter particles may be captured by a star, accumulate and subsequently annihilate, which provides the star with additional energy. This can affect the stellar evolution significantly, making stars longer-lived, as part of the stellar nuclear fusion is replaced by the energy from dark matter annihilation, disrupting the stars or even preventing them from forming. At the Galactic Center, where dark matter densities are extremely high, the dark matter capture rate is sufficiently high that the effect on the stellar evolution becomes significant and observable. We have discussed this in a recent paper [1], where we focus on main sequence stars. The purpose of the visit was to re-fine and extend our models to be able to investigate the effect on stellar evolution in more detail and beyond main sequence stars.

## 2 Research activities and outcomes

The research activity was focused on code development. For this, I wrote and implemented a custom module in the stellar evolution code `MESA` [2], that determines the dark matter capture rate and the resulting extra energy provided to the star throughout the stellar evolution. First runs of this module have been consistent with our previous results in [1], that were based on a more simplified implementation.

This new module now allows us to implement more detailed and specific dark matter models, as well as to compare our stellar evolution models to observations of stars at the Galactic Center that show several unusual characteristics: They appear younger than expected, while older, more evolved stars are missing. This has not been explained by standard stellar evolution models, but may be explained by the dark matter effects making the stars longer-lived – old stars will appear much younger, resulting in the large number of young stars and lack of old stars. With the help of our new module, we are currently investigating the details of this scenario.

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## References

- [1] Isabelle John, Rebecca K. Leane, and Tim Linden. “Dark Matter Scattering Constraints from Observations of Stars Surrounding Sgr A\*<sup>\*</sup>”. In: (Nov. 2023). arXiv: 2311.16228 [astro-ph.HE].

- [2] Bill Paxton et al. “MODULES FOR EXPERIMENTS IN STELLAR ASTROPHYSICS (MESA)”. In: *The Astrophysical Journal Supplement Series* 192.1 (Dec. 2010), p. 3. ISSN: 1538-4365. DOI: 10.1088/0067-0049/192/1/3. URL: <http://dx.doi.org/10.1088/0067-0049/192/1/3>.