

# A newly detected old, 79 day period binary places the tightest constraints on the density of the dark cusp around the Galactic center supermassive black hole.

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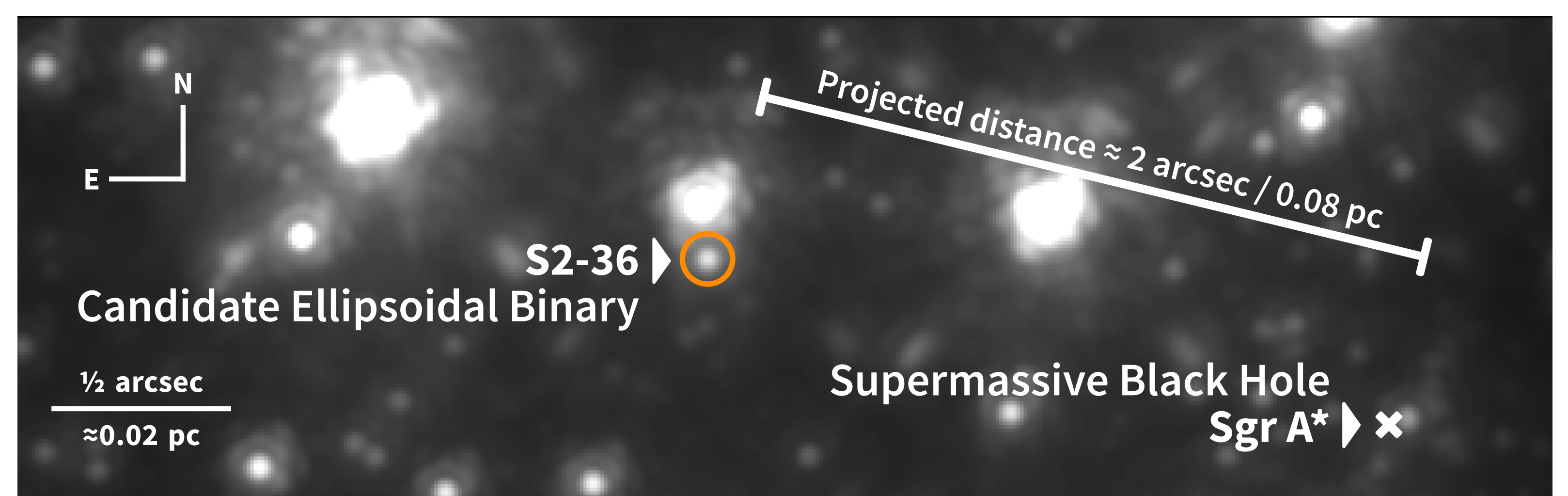
1: UCLA, 2: UC BERKELEY, 3: CALTECH

## Periodic star detected with $\approx 14$ year Keck LGSAO NIR Photometric Dataset

Imaging observations were taken with Keck NIRC2 LGSAO from 2006 to 2019 (59  $K'$ -band and 12  $H$ -band nights) of the central 10 arcsec ( $\approx 1/2$  parsec) of the Milky Way Galactic center (GC).

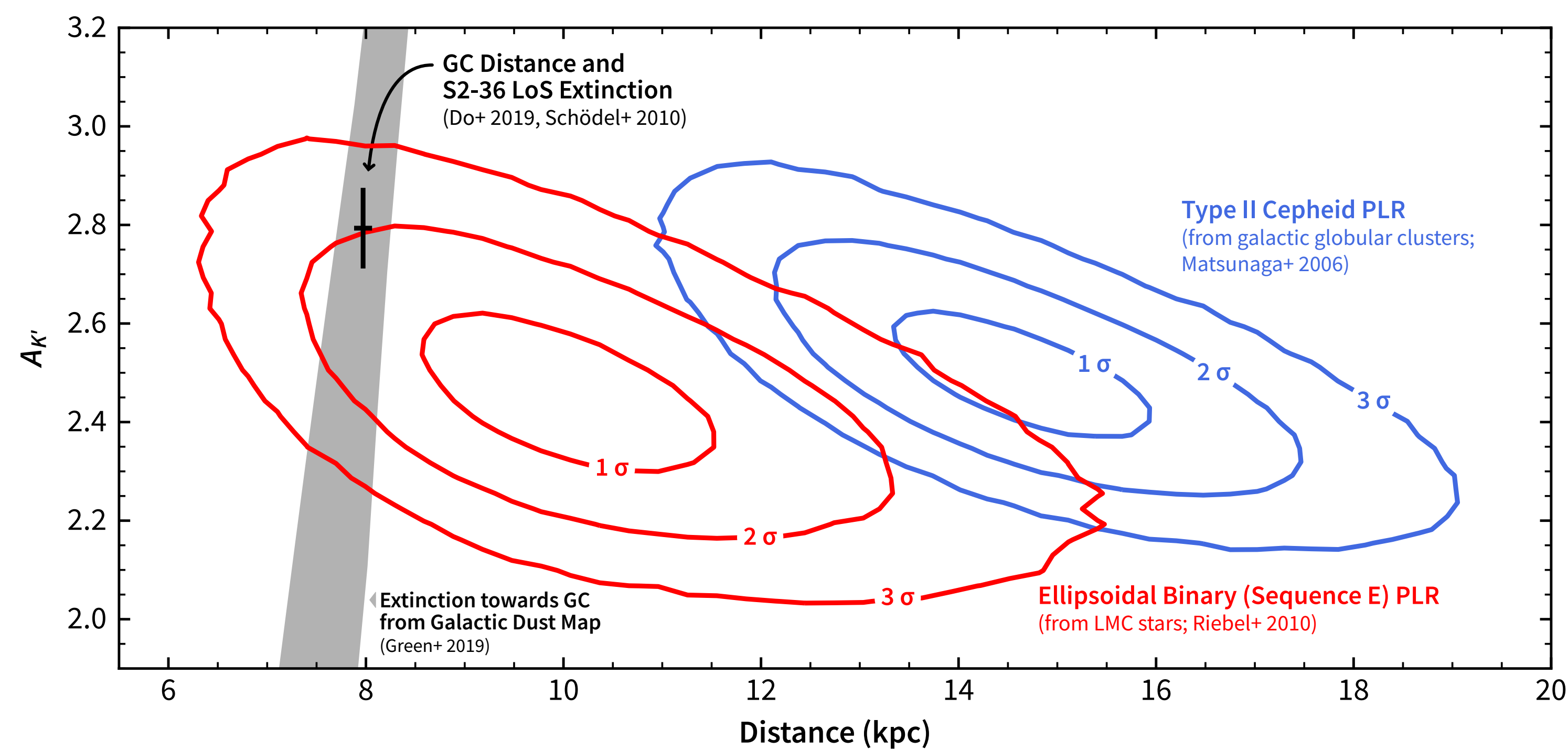
2006–2017  $K'$  data published in Gautam+ 2019 (ApJ, 871:103; arXiv:1811.04898):

- Methodology for extracting precise photometry from GC imaging data.
- Periodicity search performed on 563 stars: detect the two known GC eclipsing binaries (IRS 16SW, S4-258/E60) and a new periodic variable star: S2-36, with a  $\approx 39$  day photometric period ( $\approx 79$  day binary orbit period).



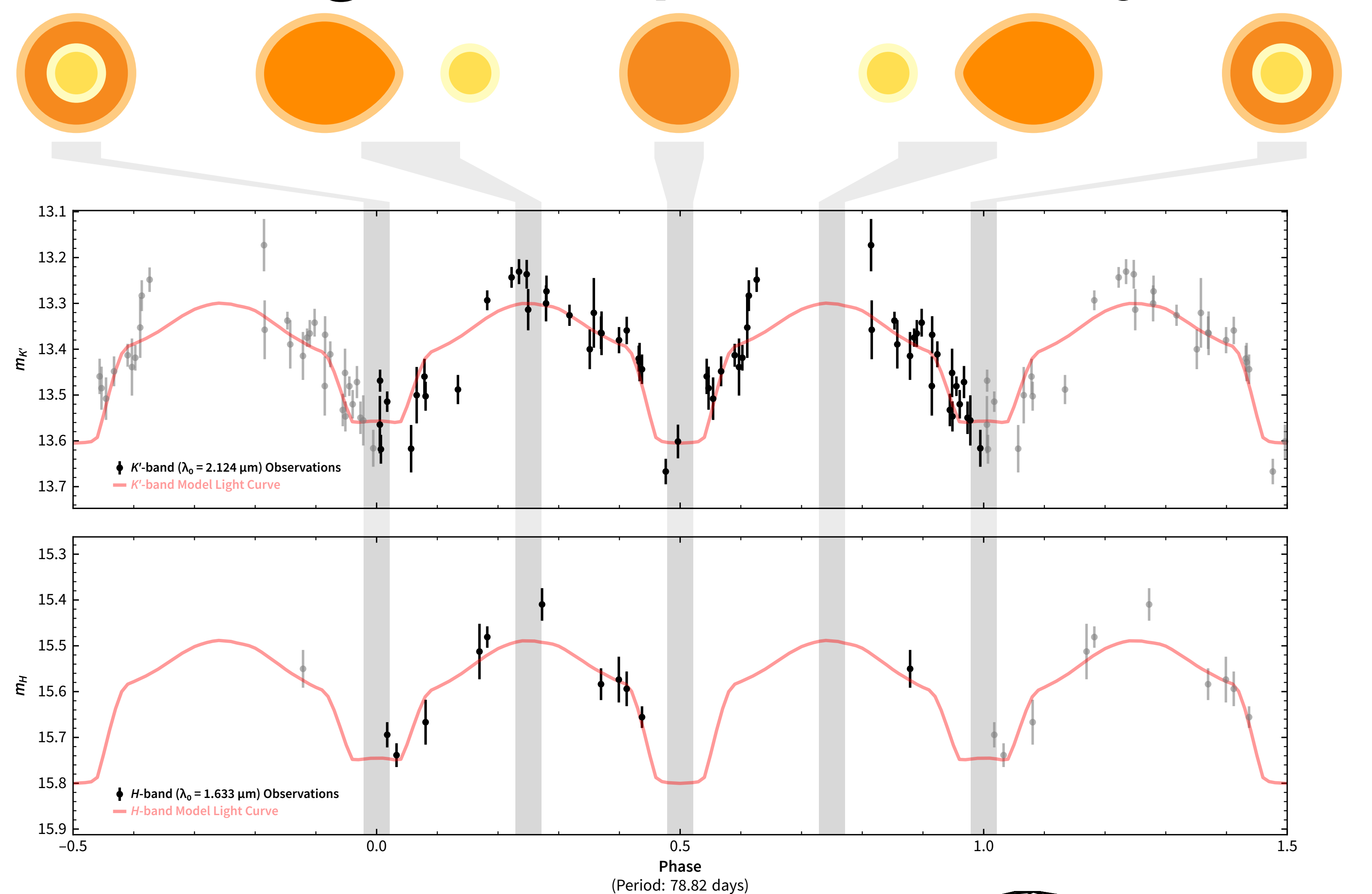
## Photometry most consistent with a red giant, ellipsoidal binary at GC

At photometric period, the observed NIR flux and color of S2-36 is most consistent with the GC distance and  $K'$  line-of-sight extinction under a red-giant ellipsoidal binary system hypothesis (aka Sequence E variable).

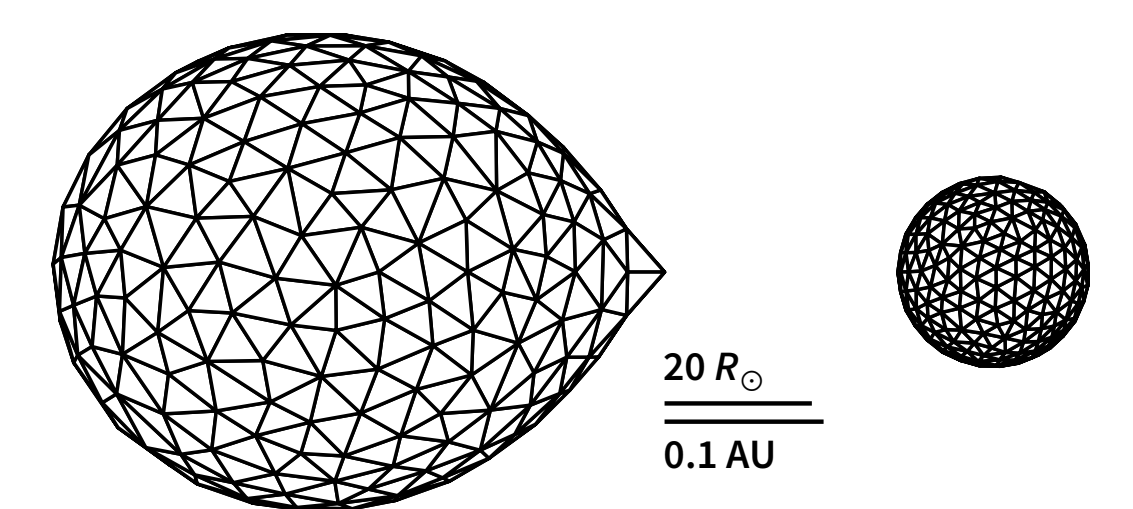


In an ellipsoidal red giant binary, the observed photometric variability comes from the changing observed flux of a tidally distorted primary rotating over the course of the binary orbit.

We developed software to model the observed  $K'$ - and  $H$ -band light curves. Binary models and light curves are generated with PHOEBE2 (Prša+ 2016), and stellar parameters are derived using POPSTAR (Hosek+ in prep.).

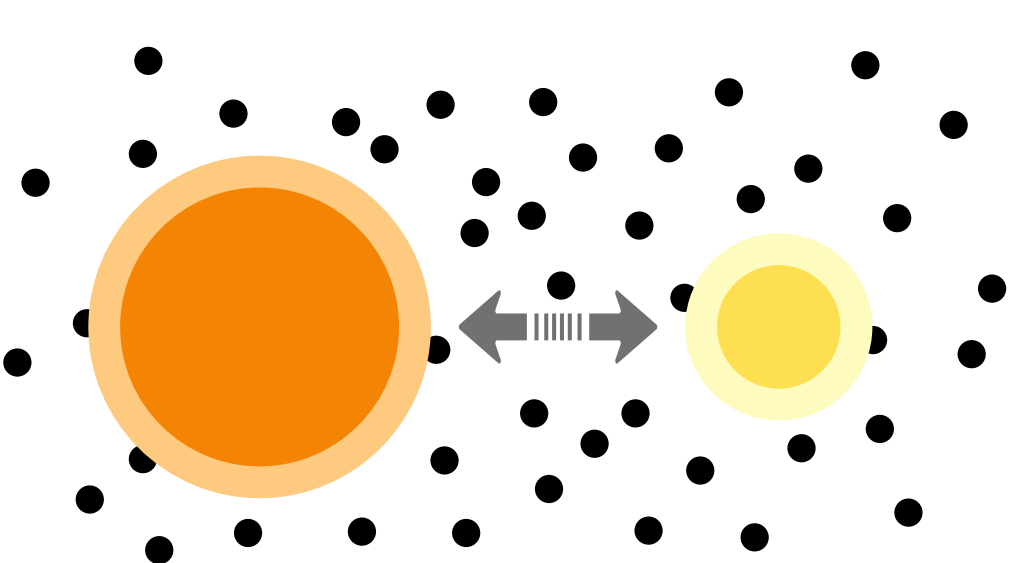


Best-fit models consist of an evolved RGB primary ( $R \approx 34 R_\odot$ ,  $M \approx 0.8 M_\odot$ ), less-evolved secondary ( $R \approx 13 R_\odot$ ,  $M \approx 0.8 M_\odot$ ), and  $\approx 0.45$  AU separation between components.



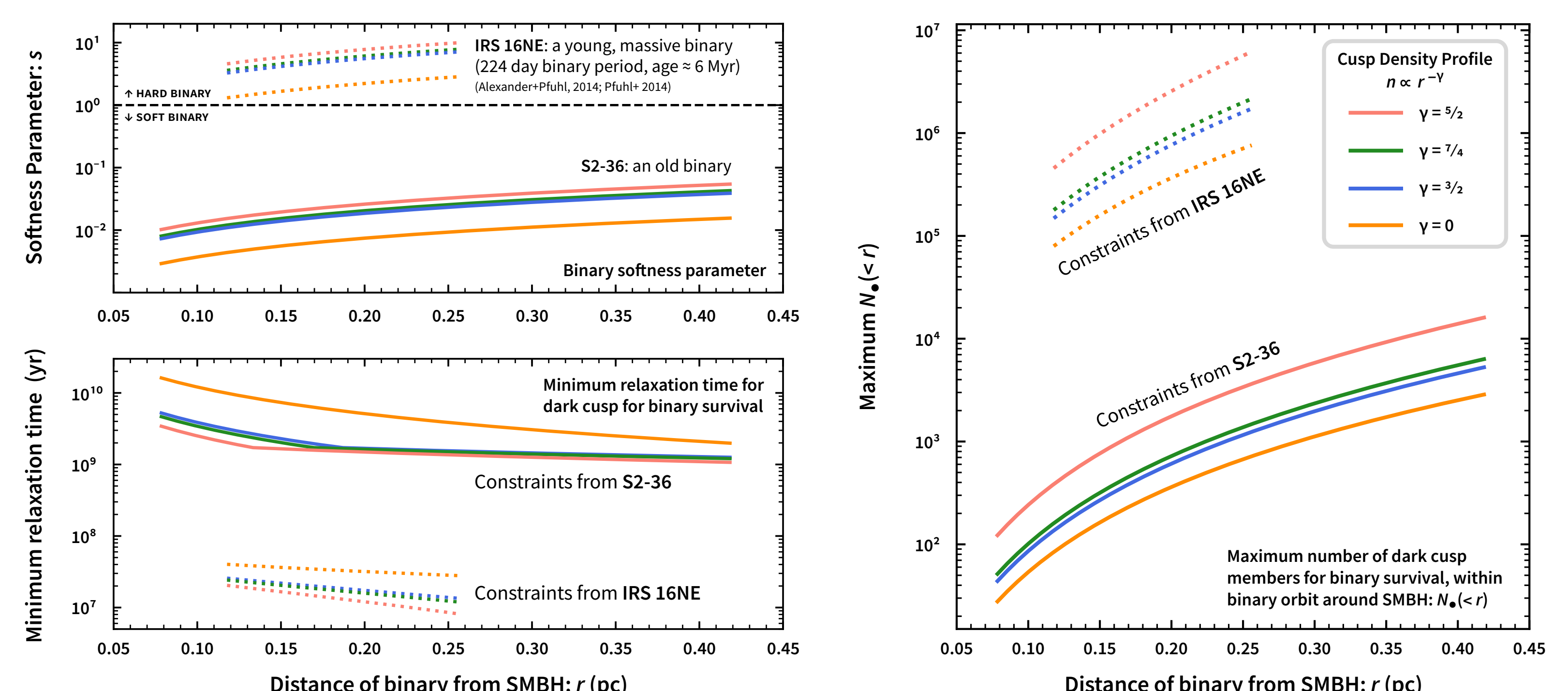
## Old binary limits dark cusp components to $\sim 10^3$ within $\approx 0.25$ pc

Dynamical models predict that recent episodes of star formation at the GC have produced a population of  $\sim 10^4$  stellar mass black holes ( $M_\bullet \sim 10 M_\odot$ ) at the GC. Once this population dynamically relaxes, we expect it to form a dark cusp, with number density of dark cusp members rapidly rising towards the center.



Soft binaries are susceptible to evaporation from interactions with surrounding field members of the dark cusp, as interactions with field members further soften the binary over its lifetime. Using estimates of the old, red giant binary system's binary orbital parameters and age ( $\sim 10$  Gyr), the survival of the binary system constrains the minimum relaxation time of the dark cusp population, and the maximum density and number of dark cusp members.

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More details about this project:

<https://abhimat.net/research/2019-10-old-binary/>



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