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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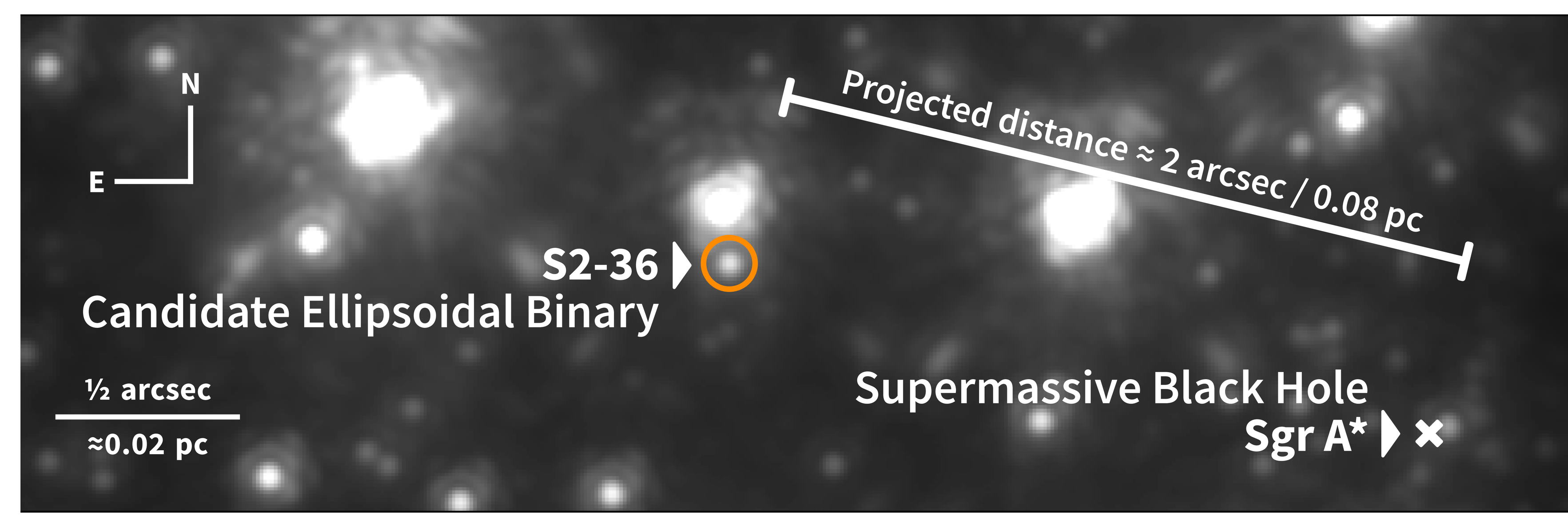
Periodic star detected with ≈14 year Keck LGSAO NIR Photometric Dataset

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 (≈½ parsec)** of the Milky Way Galactic center (GC).

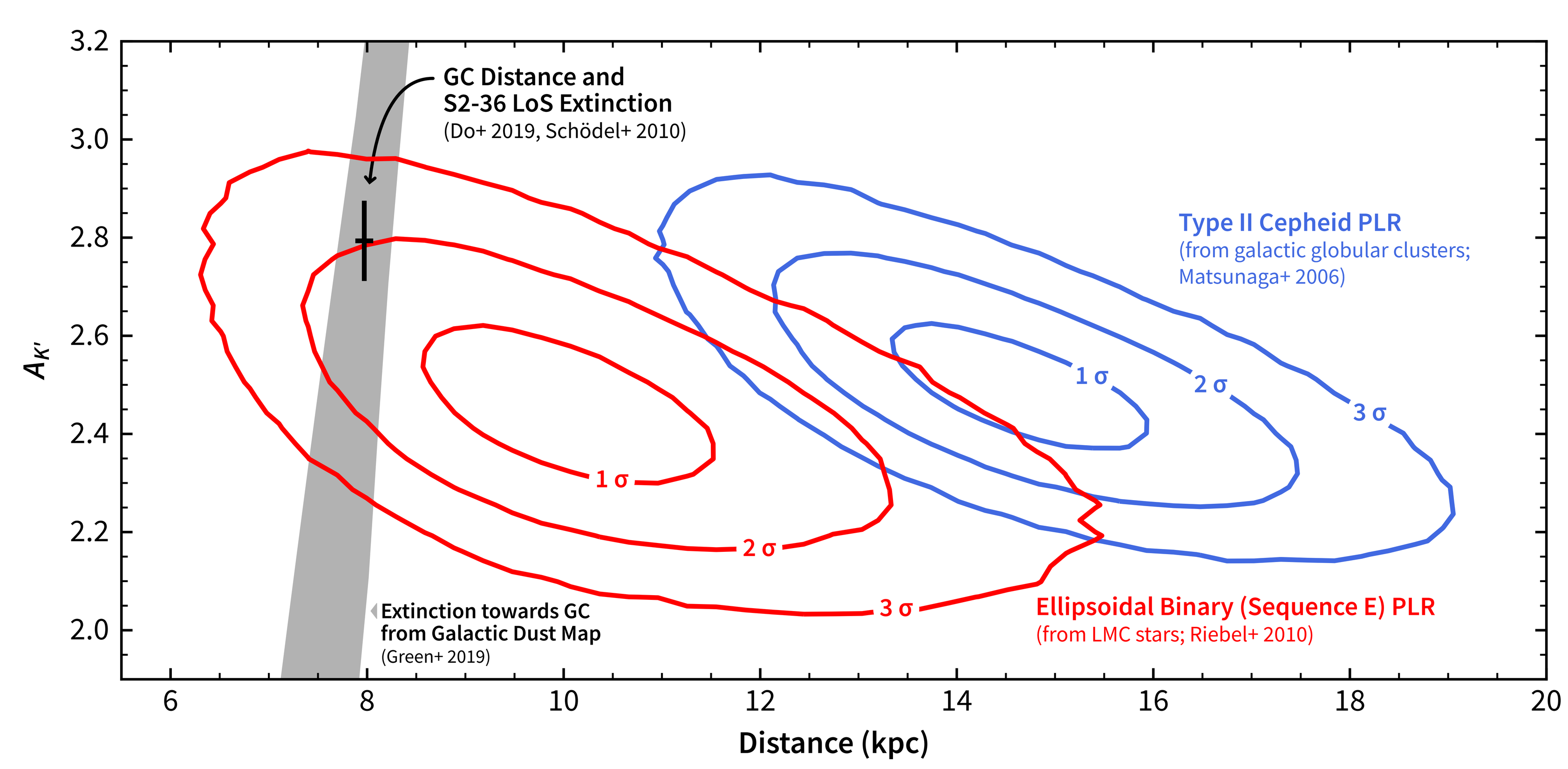
2006–2017 *K′* data published in Gautam+ 2019 (ApJ, 871:103; arXiv:1811.04898):

- 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 ≈39 day photometric period (≈79 day binary orbit period)**.



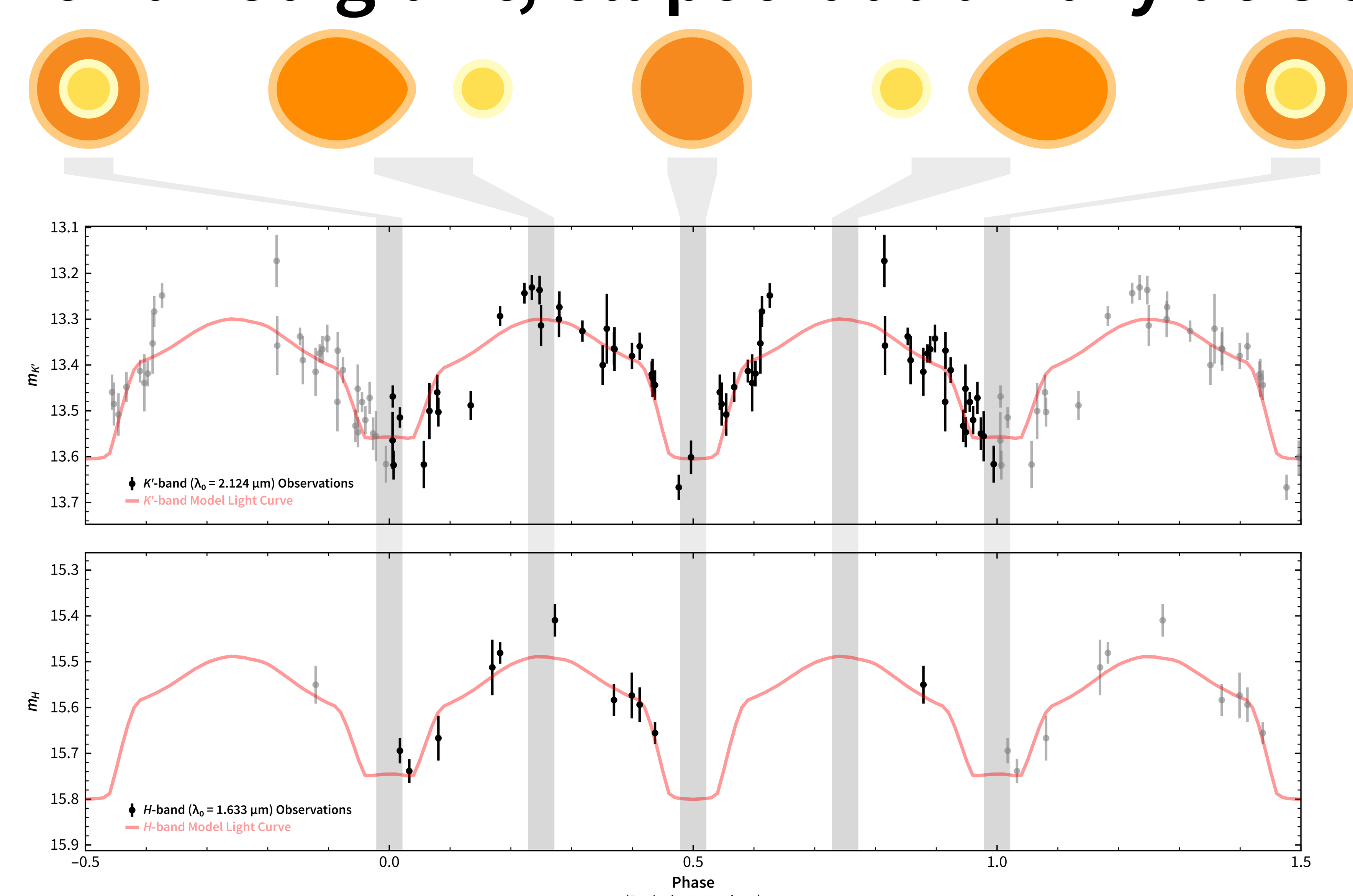
Photometry most consistent with a red giant, ellipsoidal binary at GC

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).

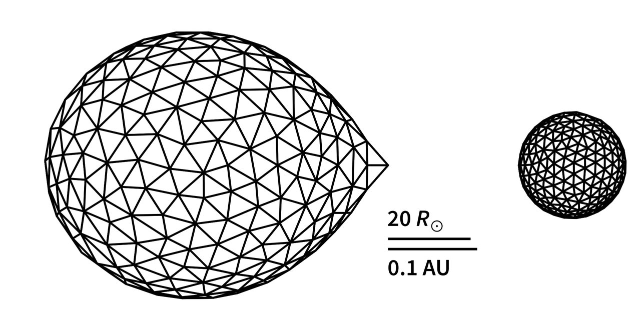


In an **ellipsoidal red giant binary**, the observed photometric variability comes from the changing observed flux of a **tidally distorted primary** rotating over the course of the binary orbit.

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., see poster).



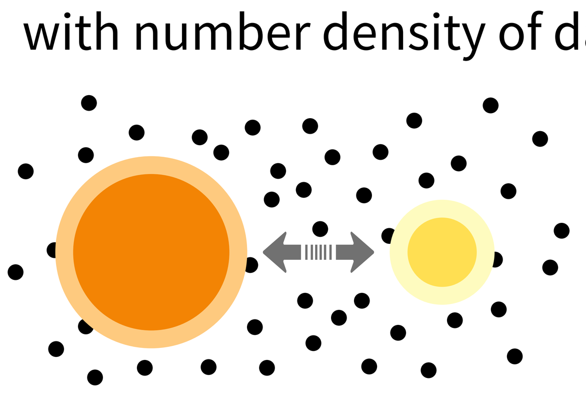
Model binary light curve (above) and **surface mesh** (right) generated from 12.8 Gyr, [Fe/H] = −0.5 stellar parameters.



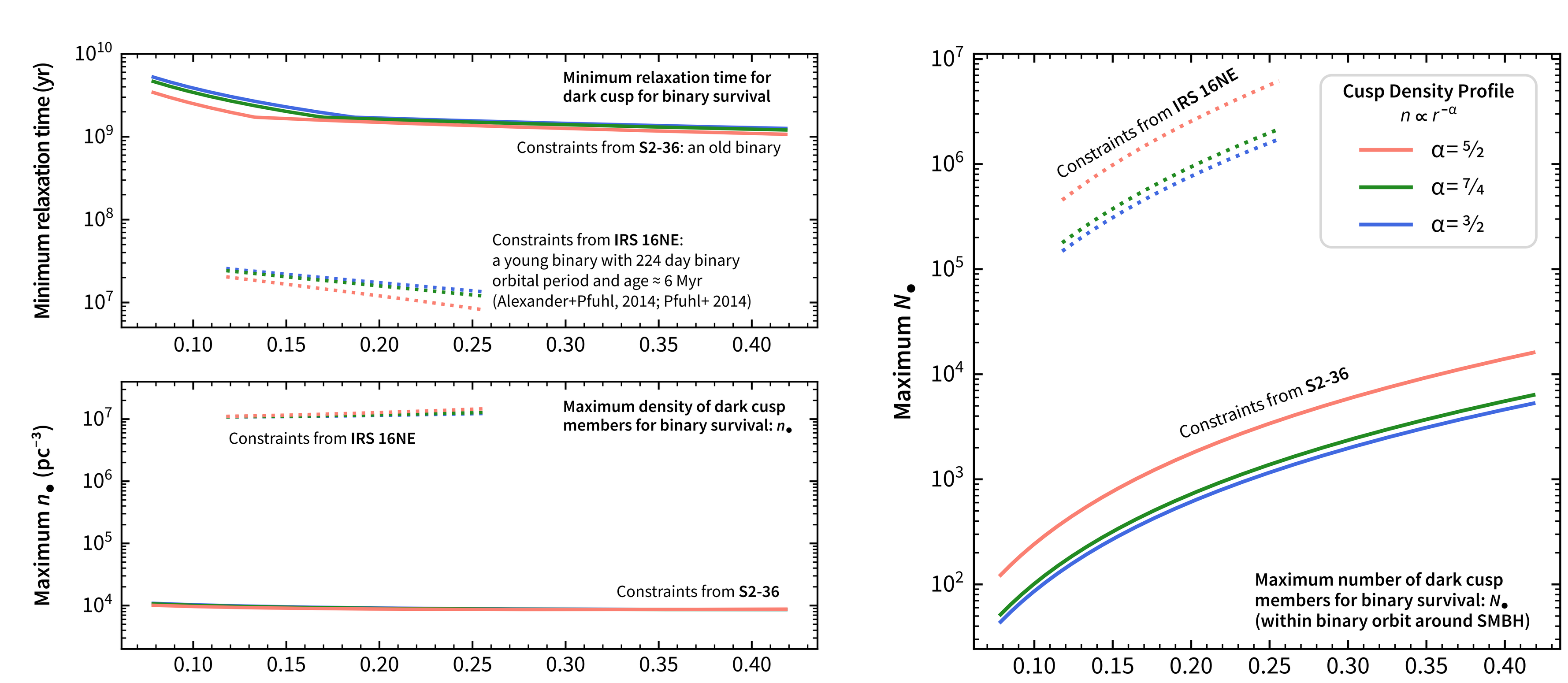
Best-fit models consist of an evolved RGB primary ($R \approx 34\ R_\odot$, $M \approx 0.8\ M_\odot$), less-evolved secondary ($R \approx 13\ R_\odot$, $M \approx 0.8\ M_\odot$), and ≈ 0.45 AU separation between components.

Old binary limits dark cusp components to ~10^3 within ≈0.25 pc

Dynamical models predict that recent episodes of star formation at the GC have produced a population of **~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 (~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.



More details about this project:
https://abhimat.net/research/2019-09-old-binary/

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