Realizing the Full Potential of Gaia Astrometry for the Characterization of the Population of Long-period Giant Planets

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30th Anniversary of the Discovery of Planet 51 Peg b
Long-period Giant Planets and their Systems
9 October 2025

Angular Astrometric Reflex

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$$\theta = \frac{M_p}{M_*}\frac{a}{d} = \left(\frac{G}{4\pi^2}\right)^{1/3}\frac{M_p}{M_*^{2/3}}\frac{P^{2/3}}{d}$$

$$= 3\ \mu\mathrm{as}\left(\frac{M_p}{M_\oplus}\right)\left(\frac{M_*}{M_\odot}\right)^{-2/3}\left(\frac{P}{\mathrm{yr}}\right)^{2/3}\left(\frac{d}{\mathrm{pc}}\right)^{-1}$$

Gaia Astrometric Precision

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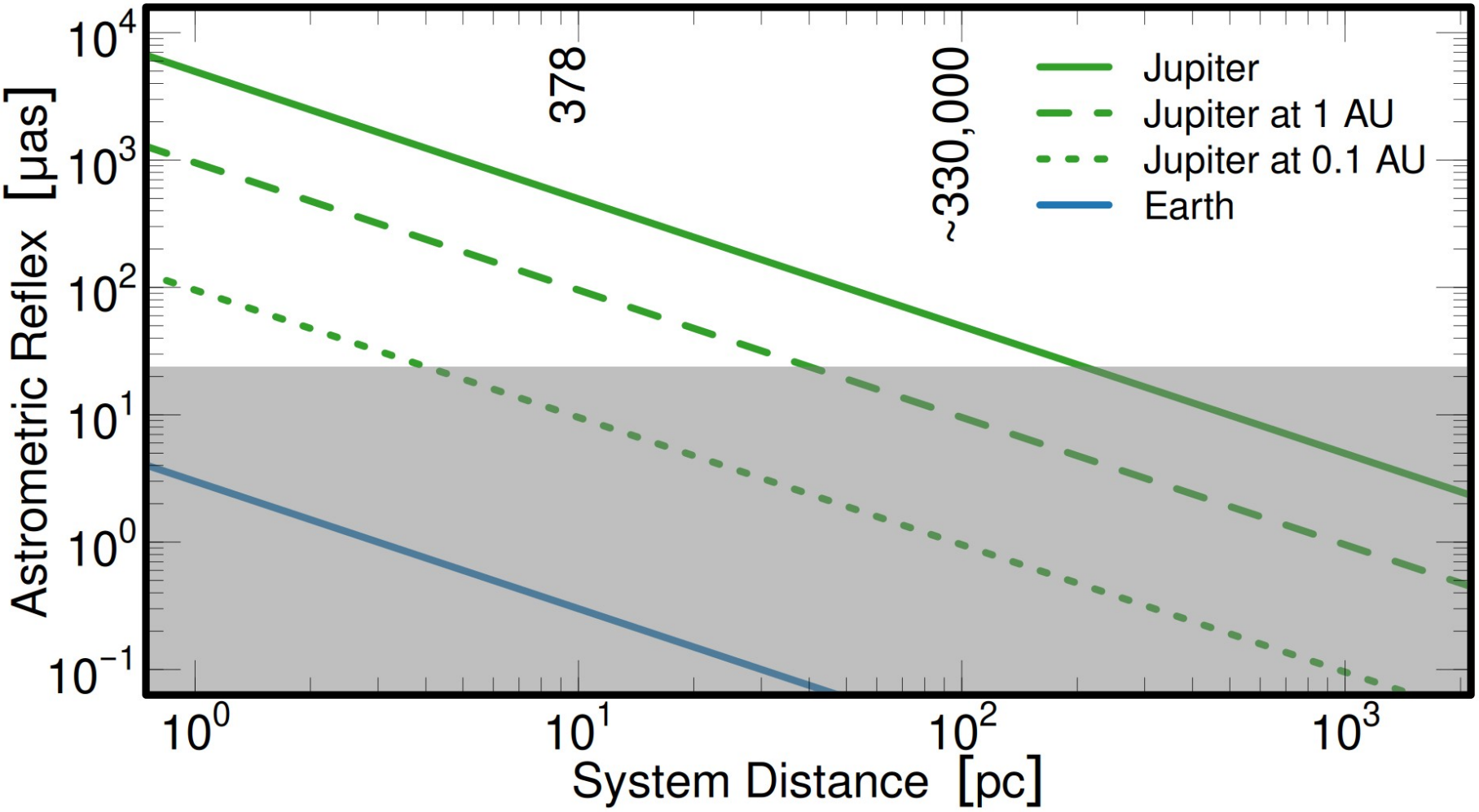
9 October 2025



Predicted Gaia Exoplanet Yield

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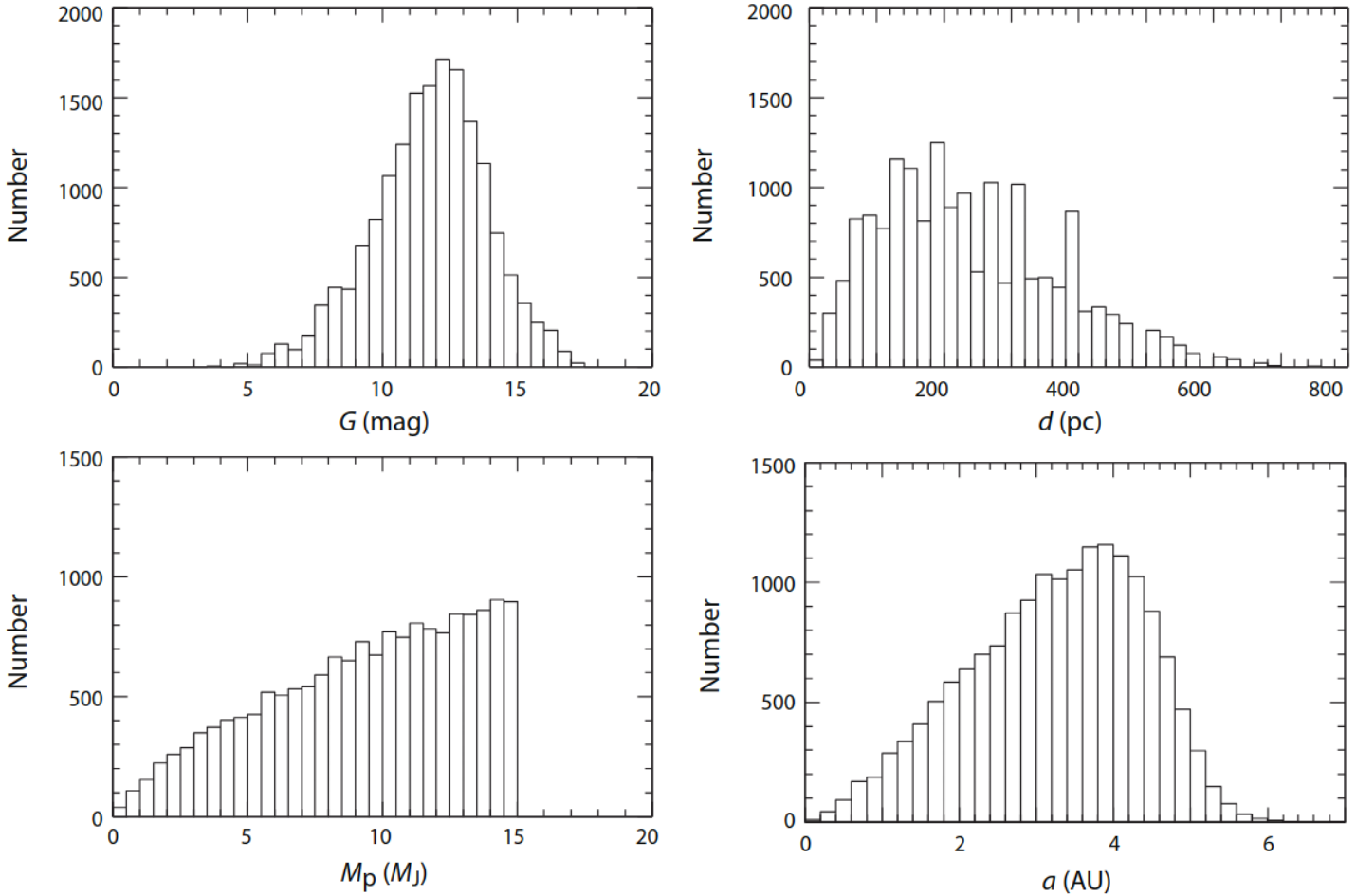

Adapted from Perryman et al. (2014)

See Caleb Lammers poster for an update

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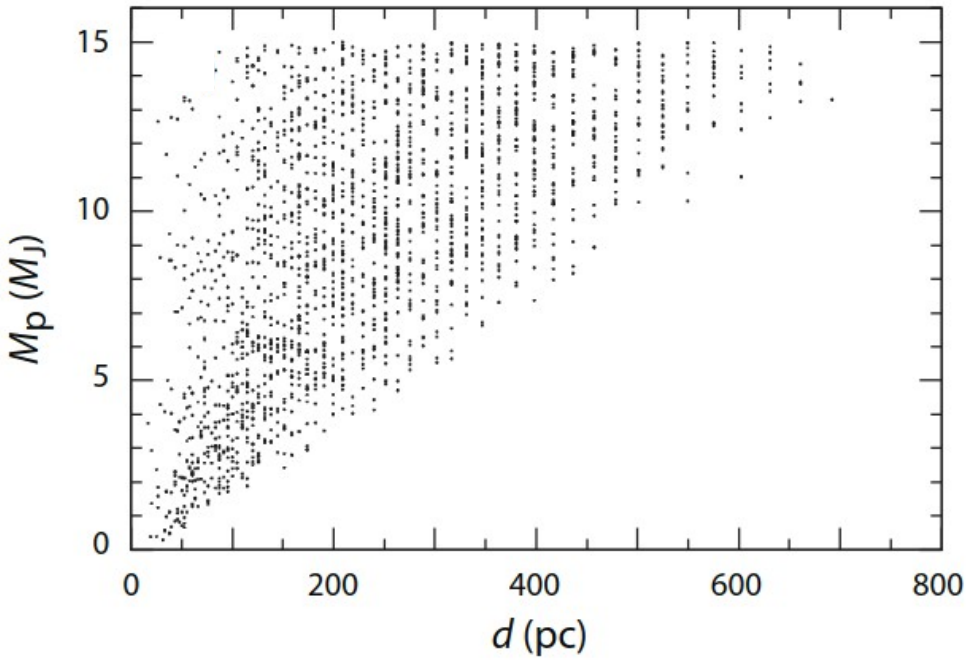

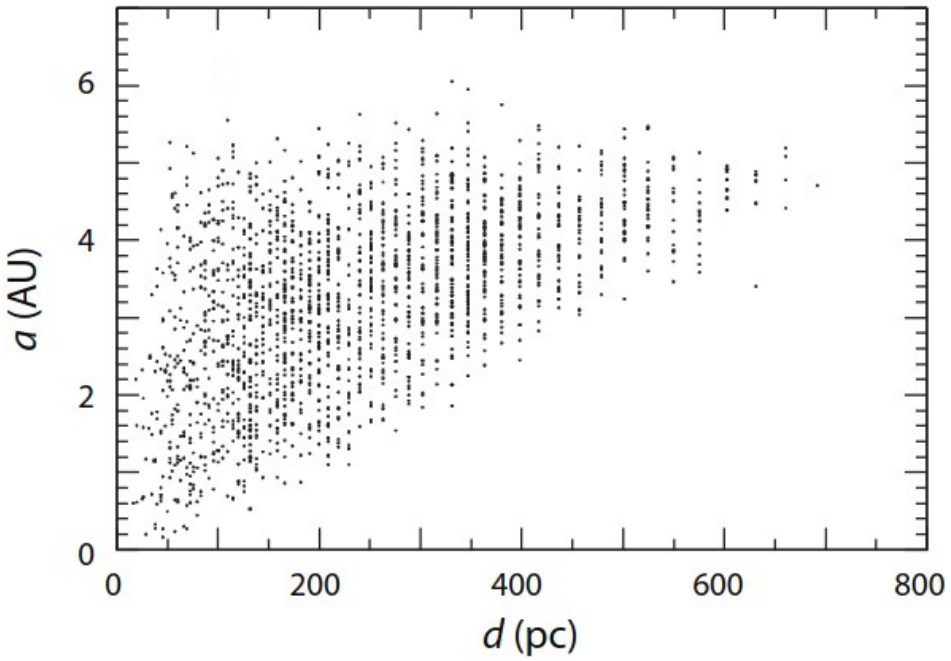

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Predicted Gaia Exoplanet Yield

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(1) 70,000 +/- 20,000 objects with M in the range 1 M_{Jup} < M < 15 M_{Jup} in the Gaia 10-year astrometric time series

(2) Orbital periods and inclinations for the majority of those objects plus masses relative to the masses of primaries; eccentricities for some

(3) Available for all types of stars for which the Doppler or transit techniques have limitations: massive stars, low-mass stars, young stars, white dwarfs, etc

Perryman et al. (2014)

Gaia DR3 ASOI

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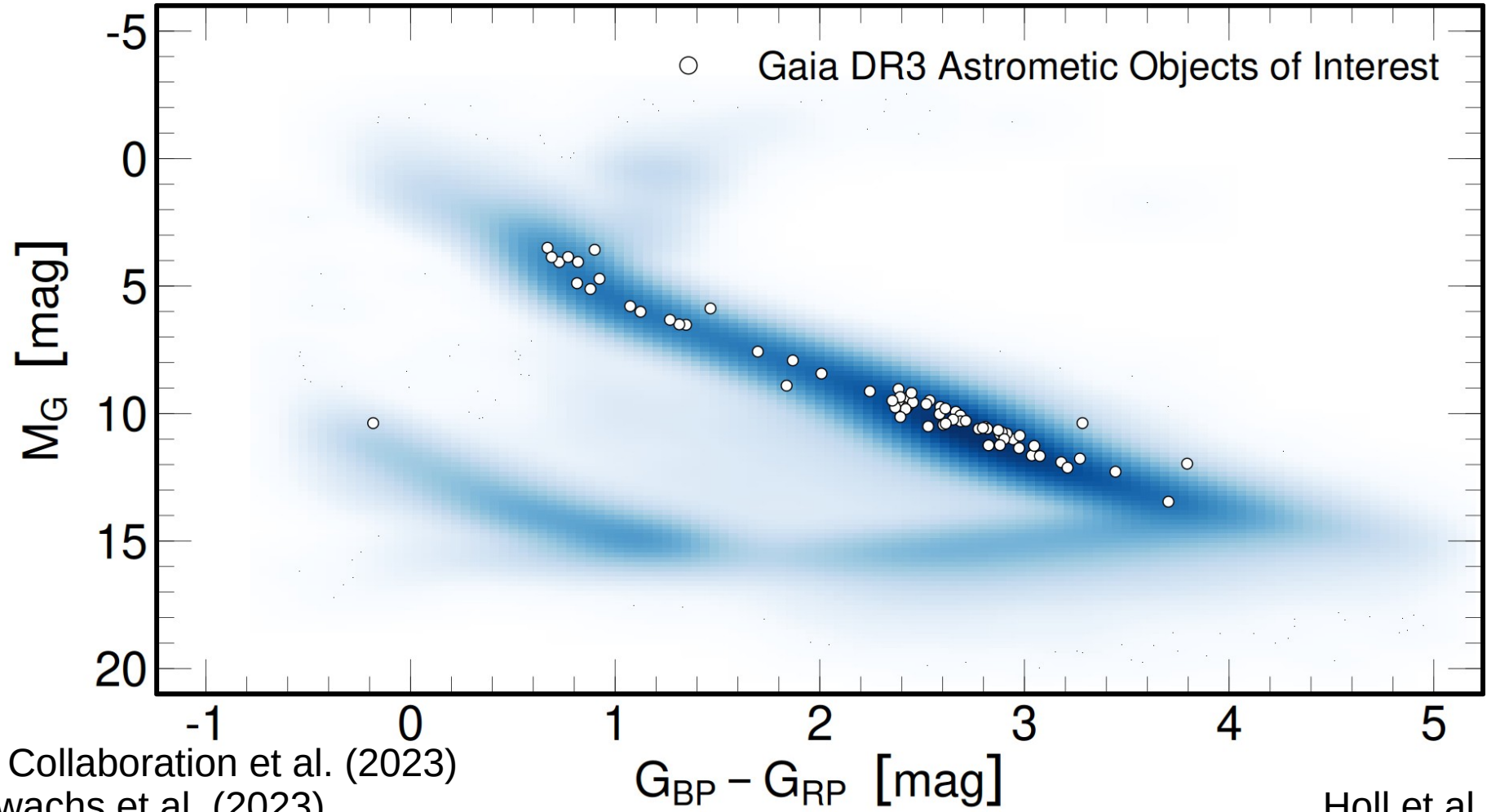

Gaia Collaboration et al. (2023)
Halbwachs et al. (2023)

Holl et al. (2023)

Gaia DR3 ASOI

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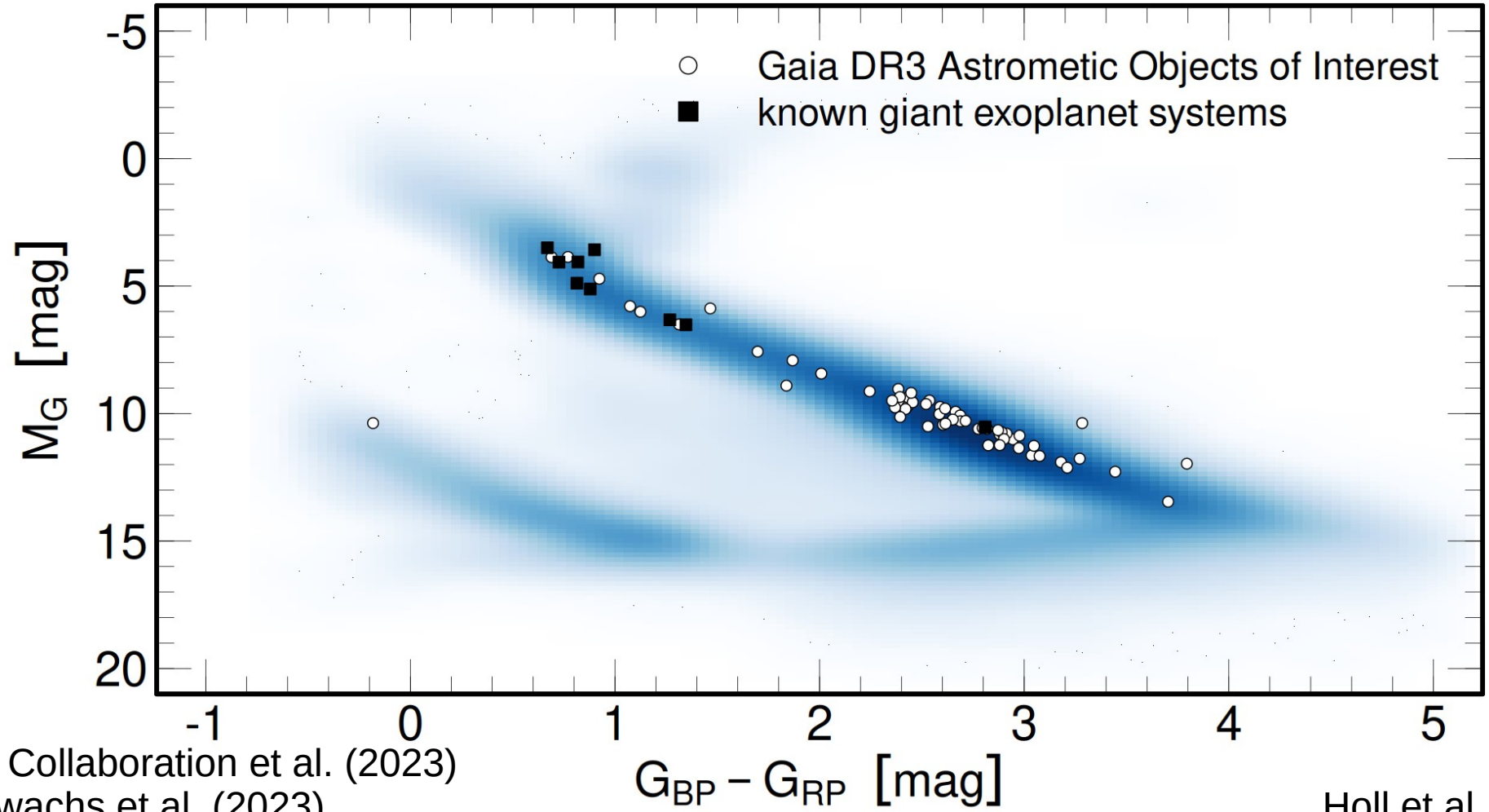

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Gaia DR3 ASOI Follow-up

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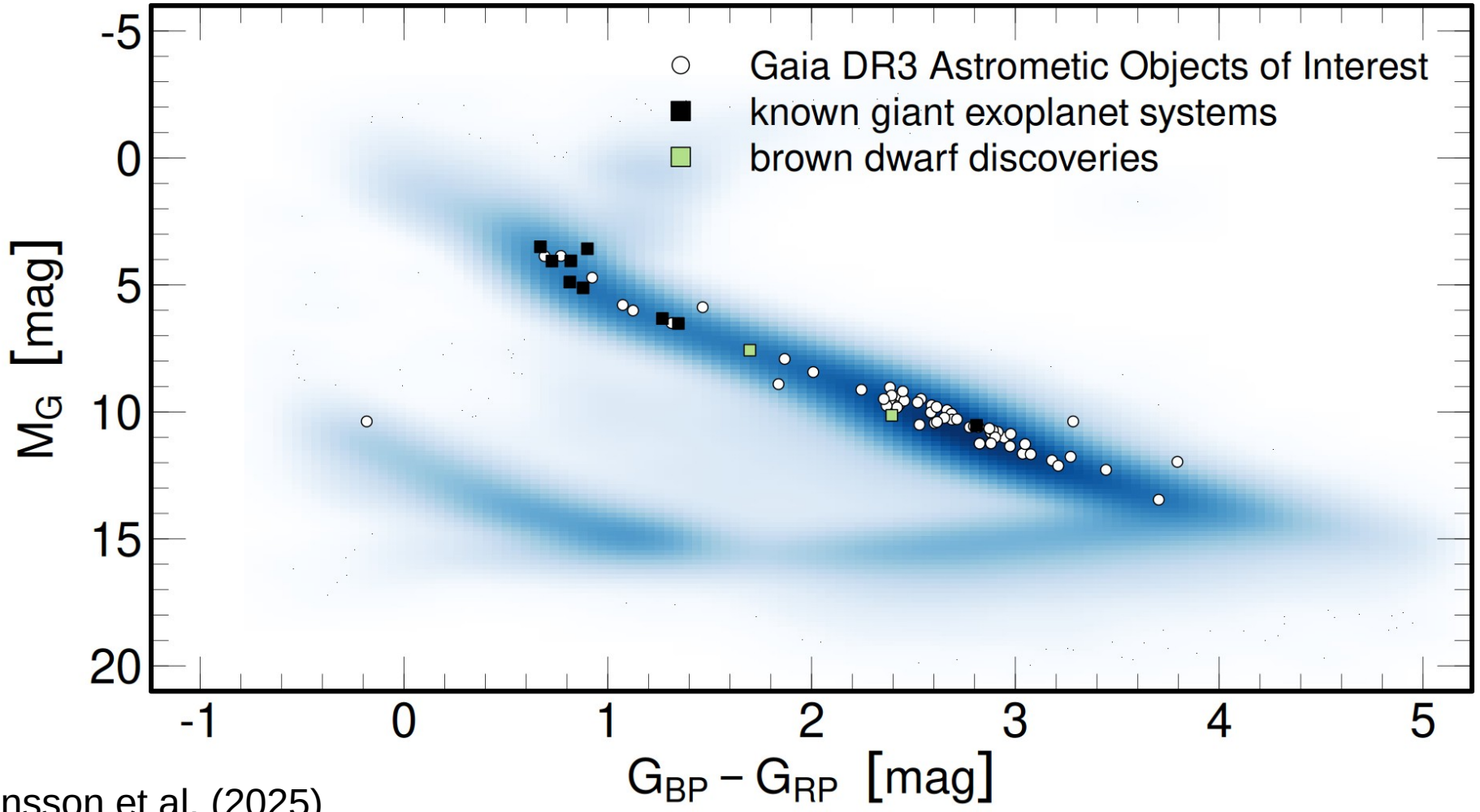

Stefánsson et al. (2025)

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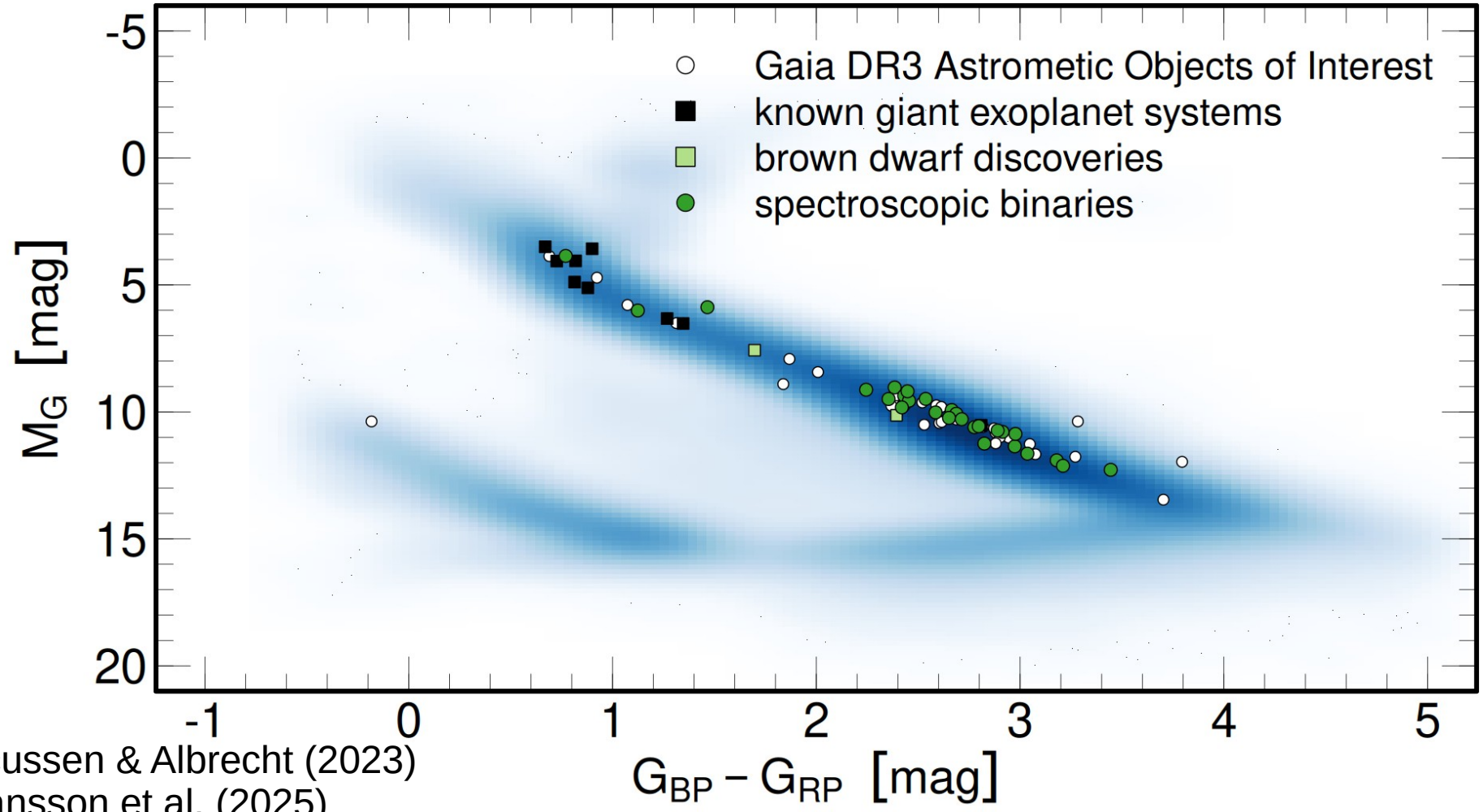

Marcussen & Albrecht (2023)
Stefánsson et al. (2025)

Equal-mass Binary Star Systems

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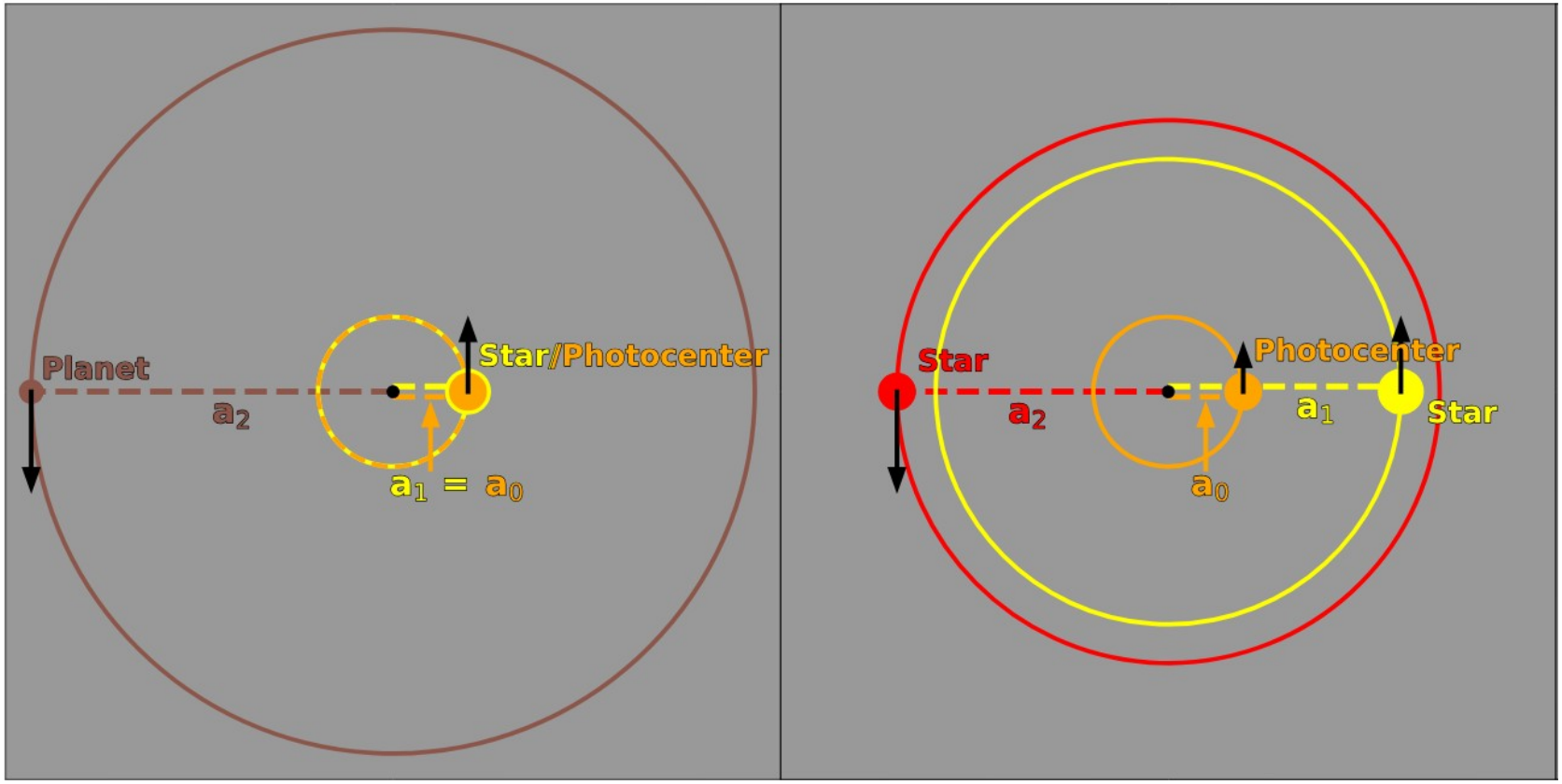
9 October 2025

Single star and giant planet

Binary star system



Adapted from Marcussen et al. (2023)

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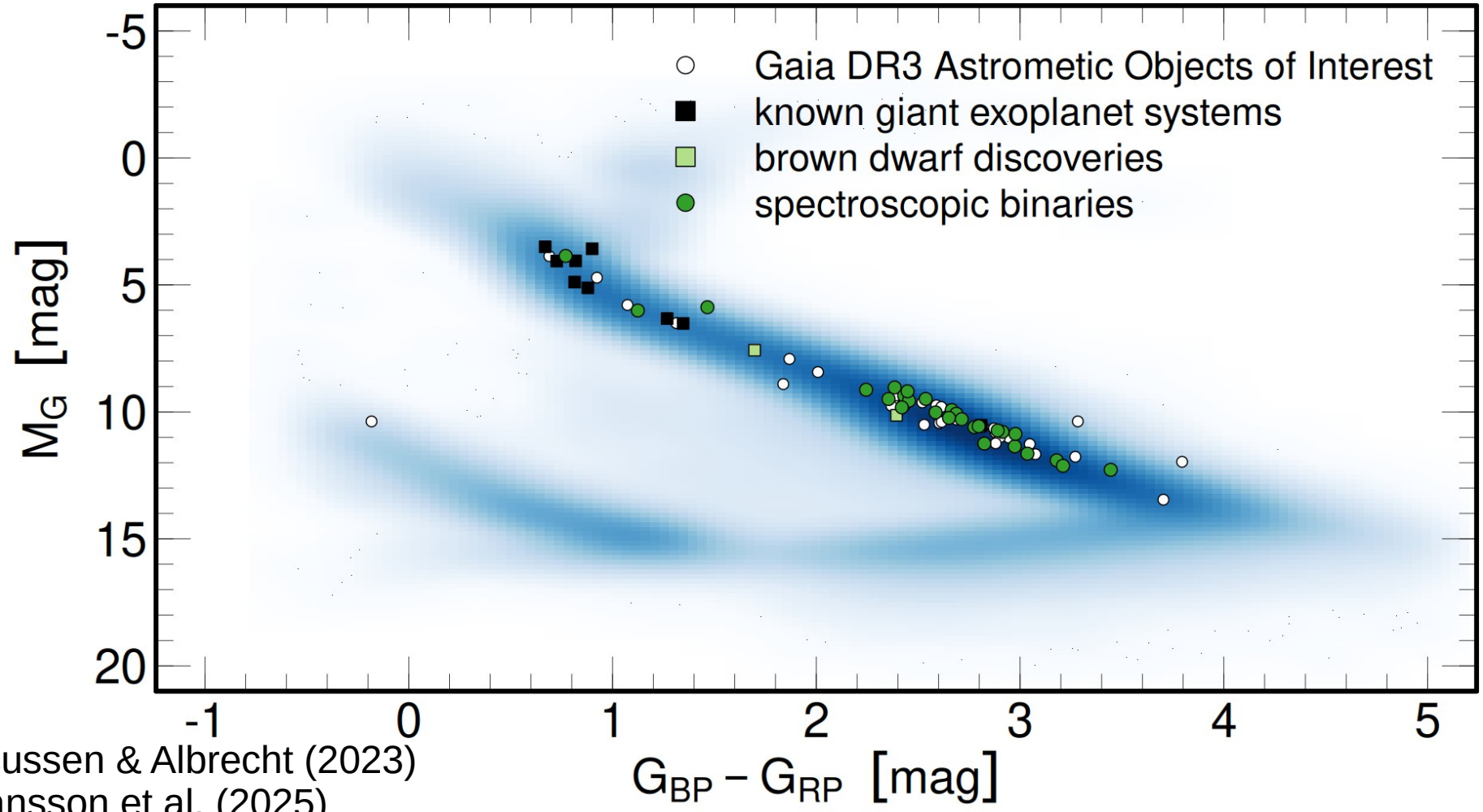

Marcussen & Albrecht (2023)
Stefánsson et al. (2025)

High Yield of SBs

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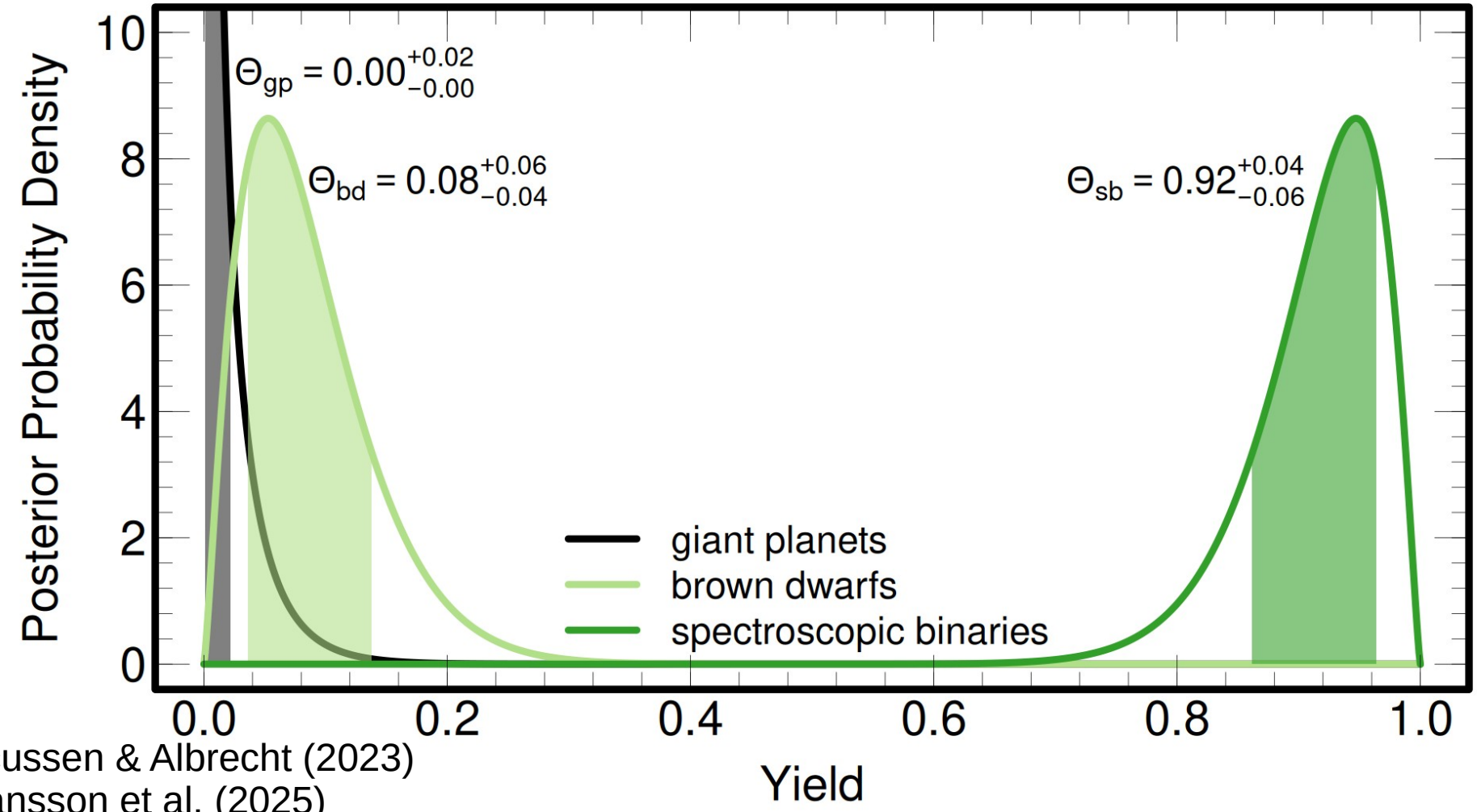

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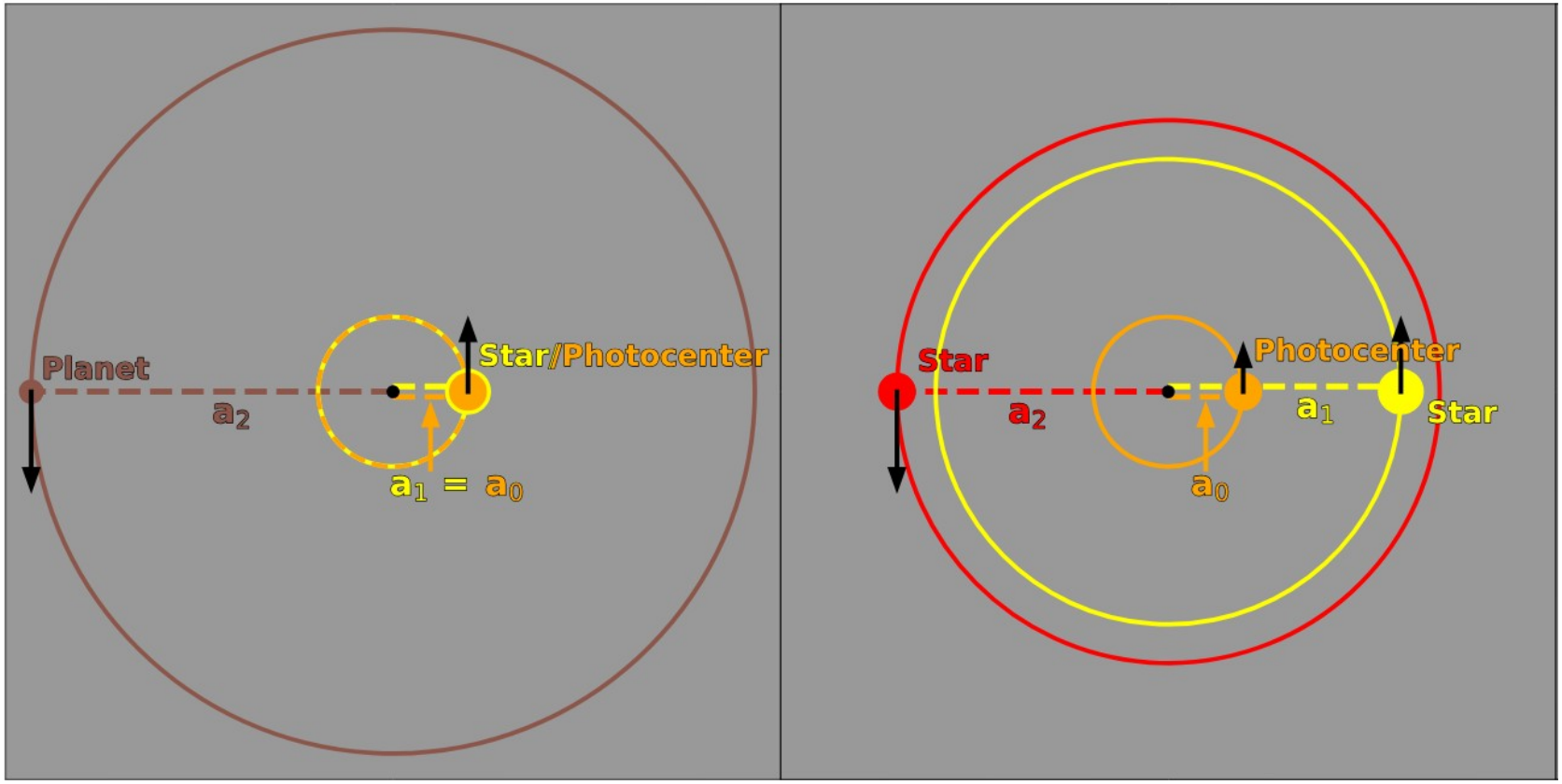

Adapted from Marcussen et al. (2023)

Fit Both Single/Binary Star Systems

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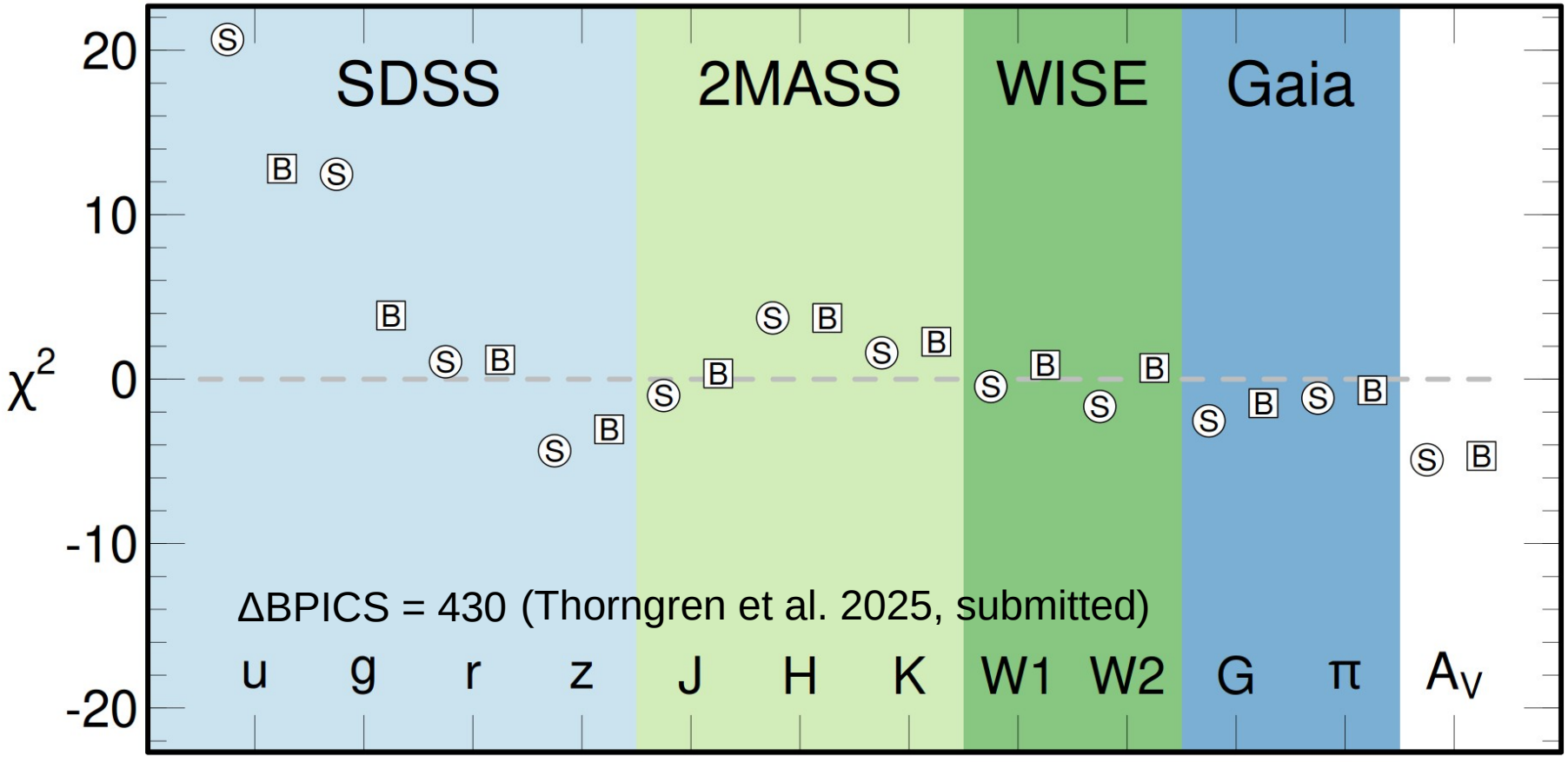

Schlaufman (2026, in prep)

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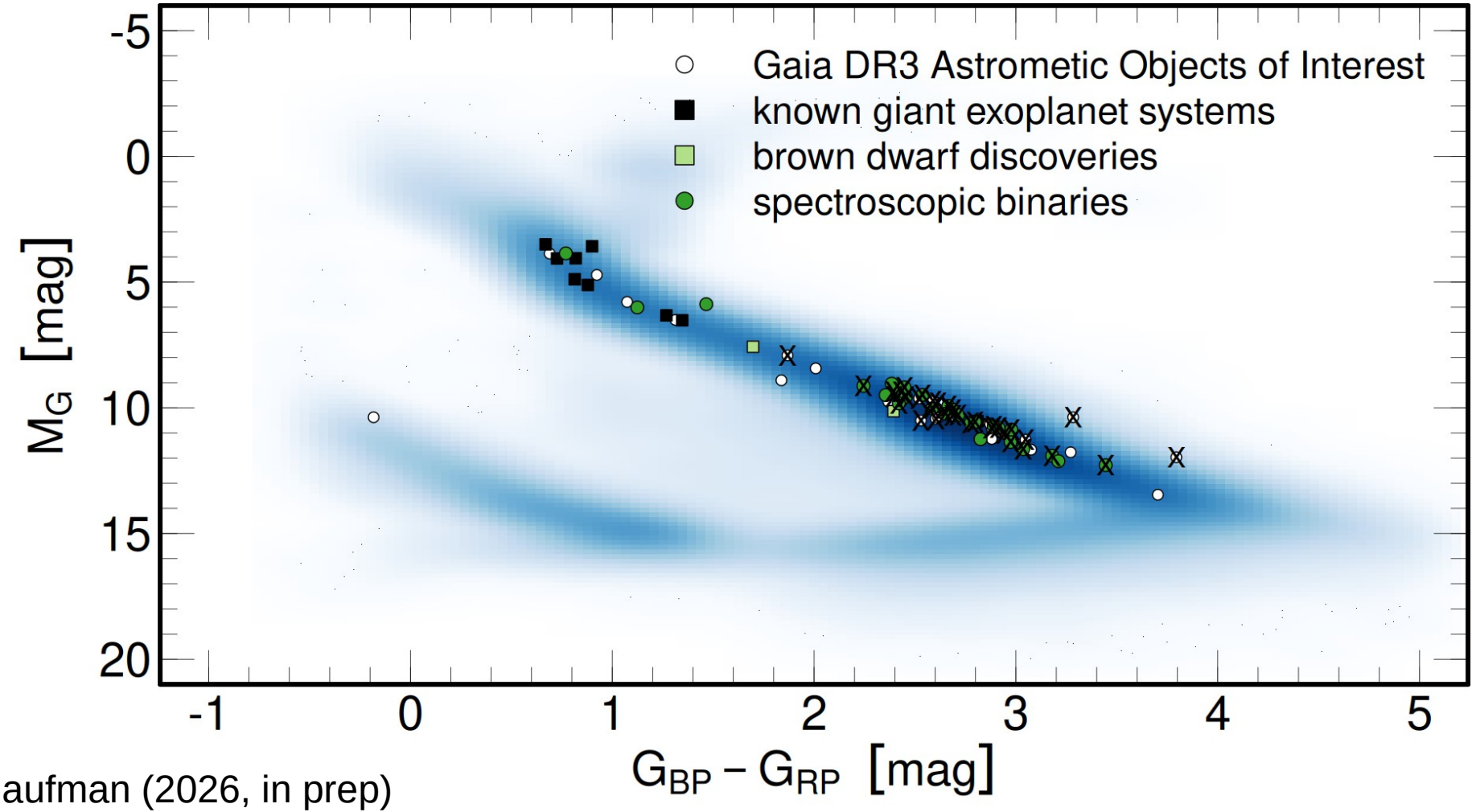

Schlaufman (2026, in prep)

17/23 SBs Correctly Identified

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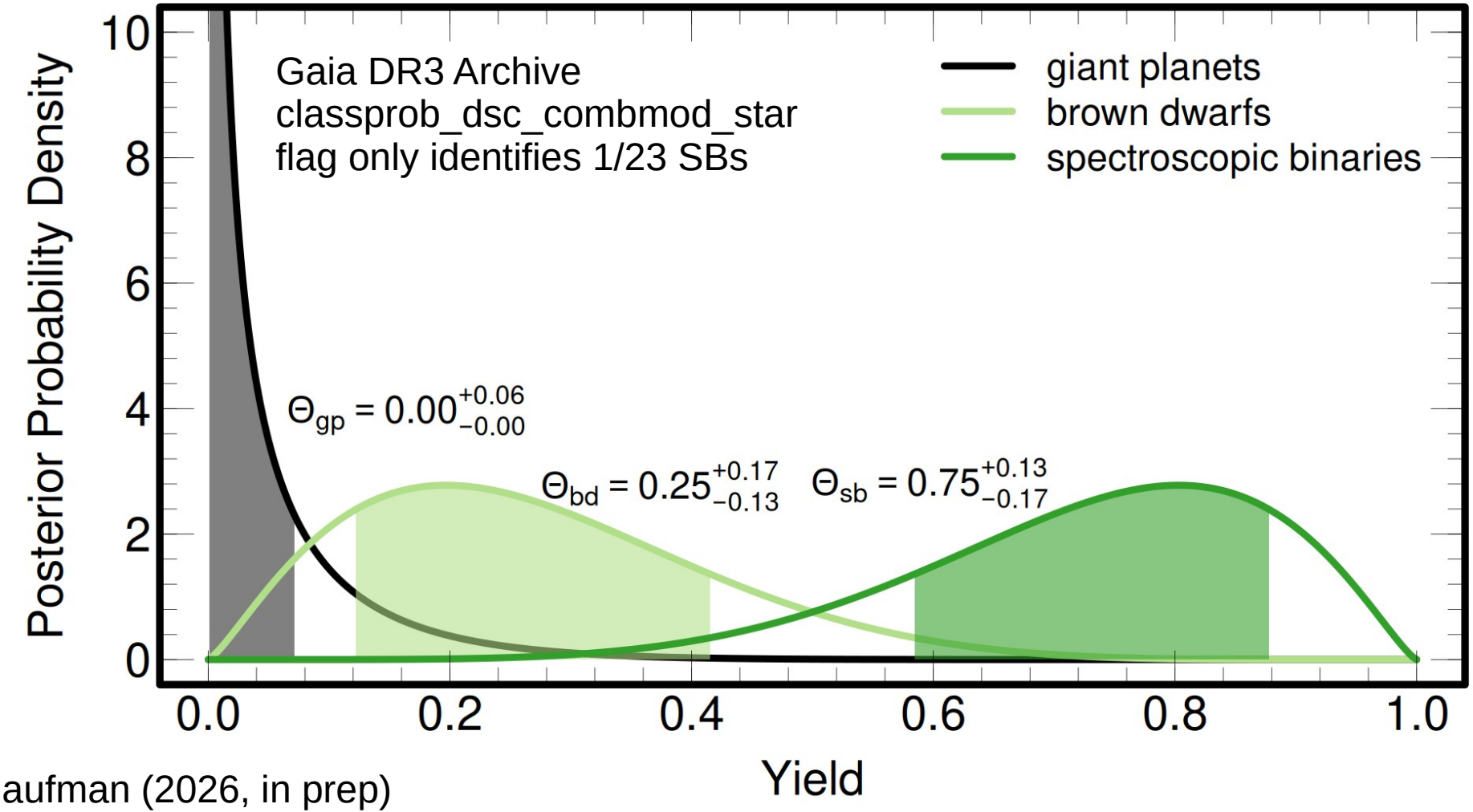

Schlaufman (2026, in prep)

Conclusions

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(1) The Gaia DR3 ASOI list is mostly equal-mass binary star systems.
(2) Expensive precision radial velocity follow-up observations have been necessary to differentiate between the ASOI planet/brown dwarf and equal-mass binary star interpretations.
(3) Fitting all available photometric, astrometric, and extinction data with both one- and two-star models allows for Bayesian model selection between the planet/brown dwarf and equal-mass binary star interpretations for Gaia ASOIs.
(4) The current procedure correctly identified 17/23 of the equal-mass binaries flagged by Stefánsson et al. (2025) without a single exoplanet/brown dwarf false positive.

Schlaufman (2026, in prep)