DISCOVERY OF A LOW-DENSITY SATURN AROUND A METAL RICH M2 TYPE STAR

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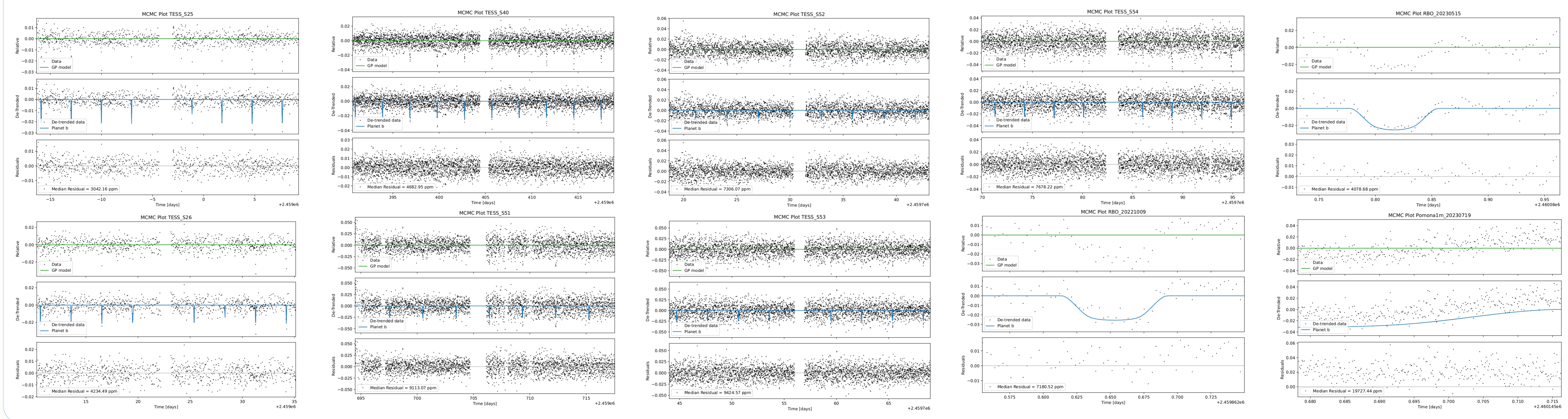
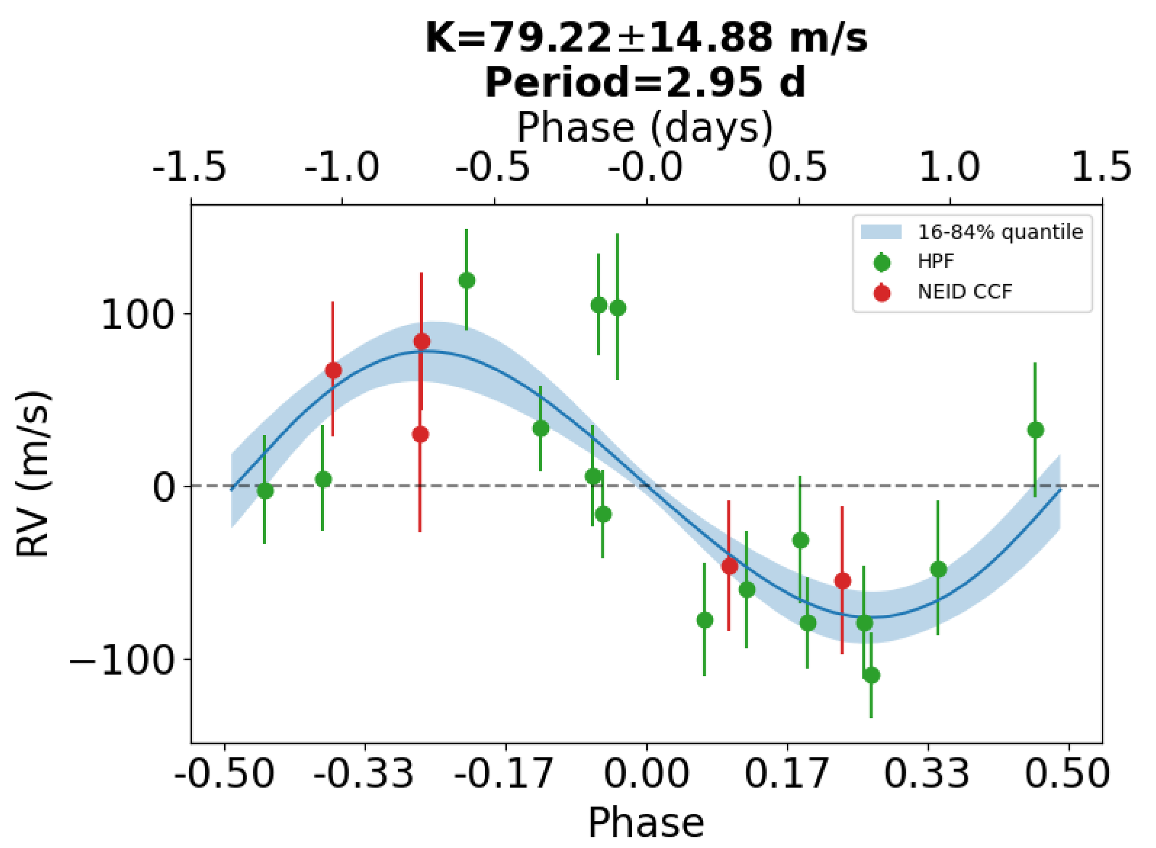
GIANT PLANETS AROUND M TYPE STARS

Compared to FGK stars, the most common type of stars in our Galaxy is M-type stars. Also, it host plenty of planets on average, compared to FGK stars. However, because of low stellar mass and large formation timescale, the detection of giant planets is not frequent around M-type stars. The Transiting Exoplanet Survey Satellite made a revolution in this by discovering numerous gas giants around M-type stars despite their rarity. Until today, we have discovered around 20 giant planets around M-type stars with precise mass measurements with radial velocity and ground-based transit follow-up. The discovery includes Neptunes, Saturns and Jupiters. We are expecting that the discovery of more such planets will help us to understand and refine the models of planet formation.(Kanodia & et al., 2023) In this poster, we are presenting the discovery of a Saturn like exoplanet with radius $10.7R_\oplus$ and mass $135M_\oplus$ revolving an M2 type star with radius $0.6R_\odot$, mass $0.6M_\odot$ $T_{eff} = 3533K$ and $[Fe/H] = 0.48dex$. The transit data were taken from TESS Full Frame Images, ground-based transit follow-up using RBO and Pomona 1m Observatory and the radial velocity follow-up using HPF mounted on HET, McDonald Observatory. The data was analysed using probabilistic programming with MCMC using `PyMC3`, and the modelling of the data was done using the package `exoplanet`. The methodology and results are the following.

TRANSITS FROM TESS, RBO AND POMONA



RV DATA

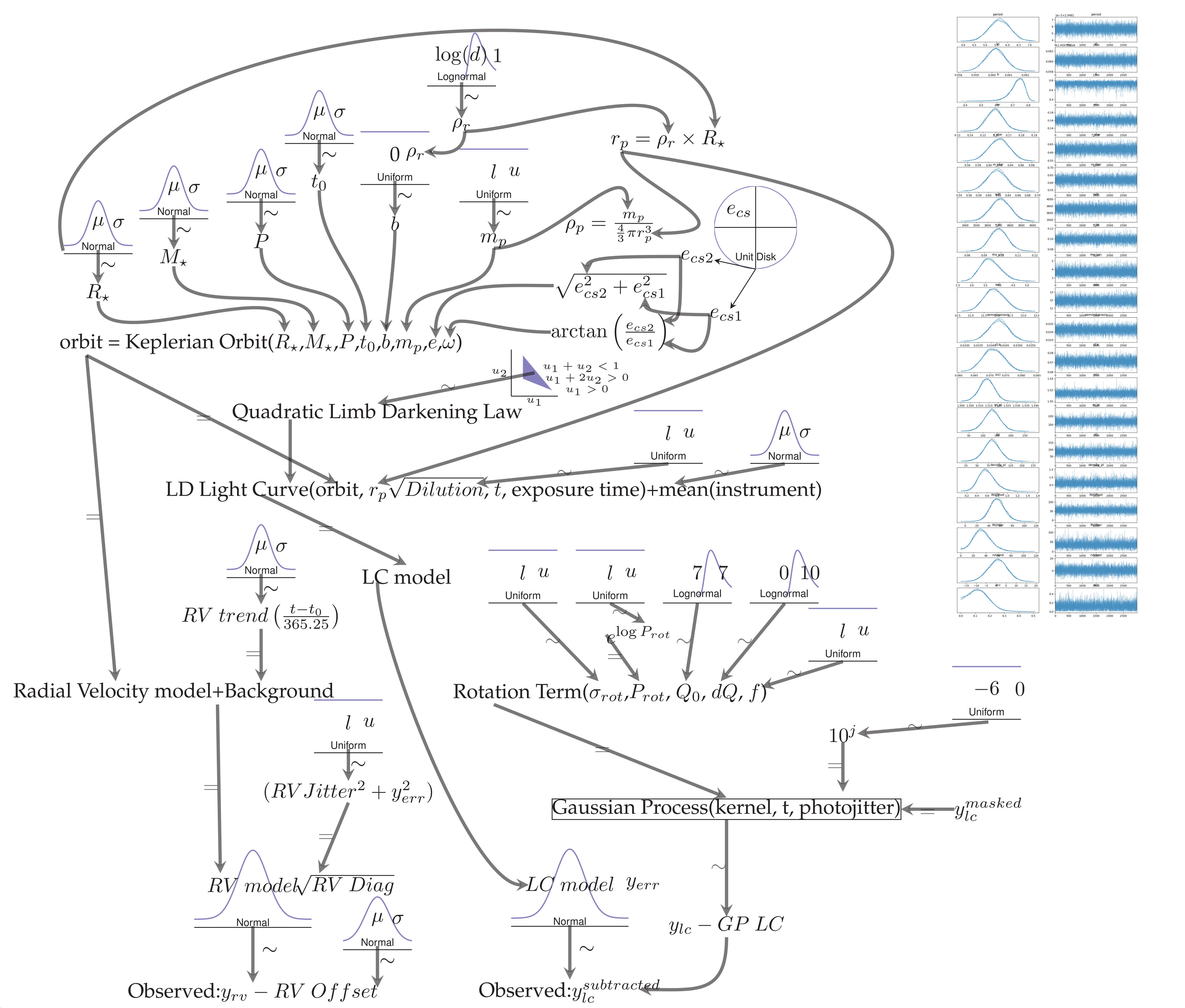


Transit data was taken from TESS, RBO and Pomona. RV data is taken with Habitable Zone Planet Finder, Mounted on Hobby Eberly Telescope in McDonald Observatory, Texas, USA.(Mahadevan et al., 2012)

MODELING

- We have Transit data from TESS, RBO and Pomona.
- Transit can give planet radius, impact parameter etc.
- RV was taken with HPF.
- RV can give the mass of the planet, eccentricity etc.
- Use both sets of data simultaneously for the modelling.
- Defined the model using the python package `exoplanet`.
- MCMC was done with the model and data using `pyMC3`. A graph of Priors, likelihood, model and posterior is shown.

BAYESIAN MODEL DIAGRAM OF THE ANALYSIS



STELLAR AND PLANETARY PARAMETERS

Parameter	Value	Source
Stellar Parameters:		
Mass($M_\odot$)	0.629 ± 0.025	SED fitting
Radius($R_\odot$)	0.605 ± 0.019	SED fitting
$T_{eff}(K)$	$3713 \pm 88K$	HPF SpecMatch
log(g)	4.69 ± 0.05	HPF SpecMatch
$[Fe/H]$ (dex)	0.47 ± 0.12	HPF SpecMatch
Planet Parameters:		
Mass($M_\oplus$)	$135.29^{+28.52}_{-28.29}$	MCMC
Radius($R_\oplus$)	$11.14^{+0.59}_{-0.63}$	MCMC
Density(g/cm^3)	$0.59^{+0.17}_{-0.15}$	MCMC
Period(days)	2.948	MCMC
Semimajor Axis(AU)	0.0343	MCMC
Eccentricity	$0.119^{+0.076}_{-0.070}$	MCMC

planet orbiting a super-solar metallicity mid dwarf. , 167(1), 4. doi: 10.3847/1538-3881/ad09c2

Kanodia, S., & et al., S. M. (2023, feb). TOI-5205b: A short-period jovian planet transiting a mid-m dwarf. *The Astronomical Journal*, *165*(3), 120. doi: 10.3847/1538-3881/acabce

Mahadevan, S., Ramsey, L., Bender, C., Terrien, R., Wright, J. T., Halverson, S., … Deshpande, R. (2012, September). The habitable-zone planet finder: a stabilized fiber-fed nir spectrograph for the hobby-eberly telescope. In I. S. McLean, S. K. Ramsay, & H. Takami (Eds.), *Ground-based and airborne instrumentation for astronomy iv.* SPIE. Retrieved from `http://dx.doi.org/10.1117/12.926102` doi: 10.1117/12.926102

POSITION IN PARAMETER SPACE

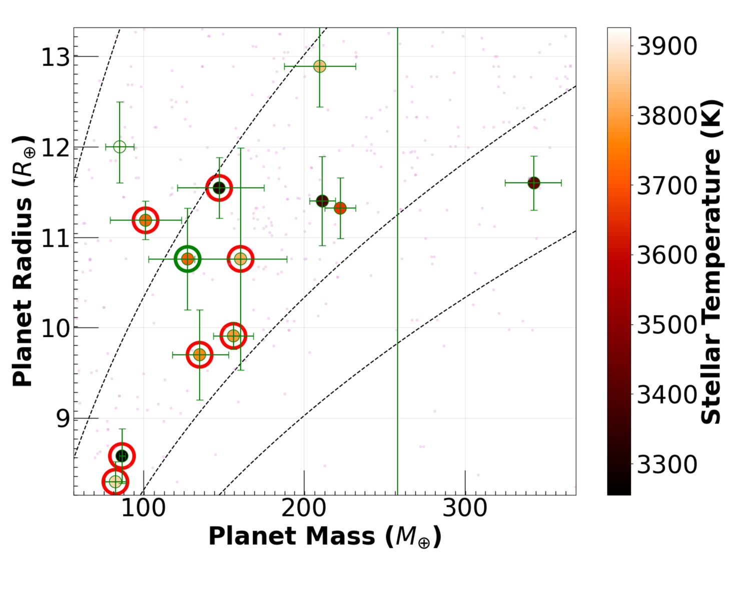


Figure 1: Radius-Mass plot of GEMS planets

- The position of the target in the Mass-Radius plane shows the characters of a Saturn-like exoplanet with a density of $\sim 0.6g/cm^3$.
- The target is located at the bottom-right region of the Metallicity-Density plot. This portion is dominated by GEMS saturns that support the Core-accretion planet formation model.
- At the time of the formation of the planet, accretion of gas and dust is heating up the protoplanet. However, because of high metallicity, the heat dissipation will be inefficient. This leads to heating up the protoplanet and stops further accretion.(Han & et al., 2024)

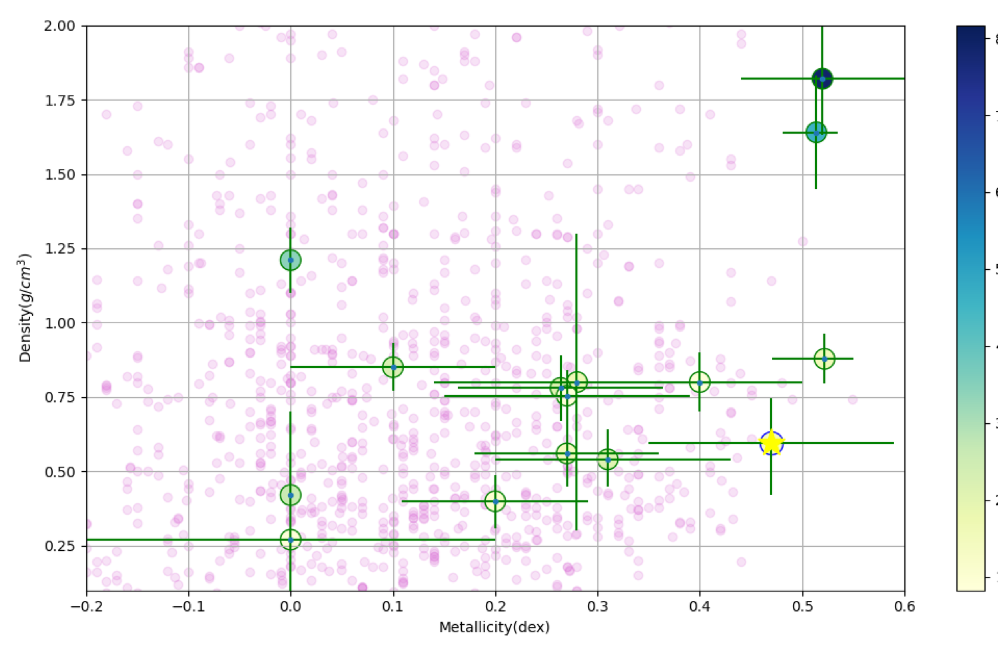


Figure 2: Metallicity of host star vs Density of GEMS Planets.