The Distribution of Semi-Detached Binaries. I.An Efficient Pipeline

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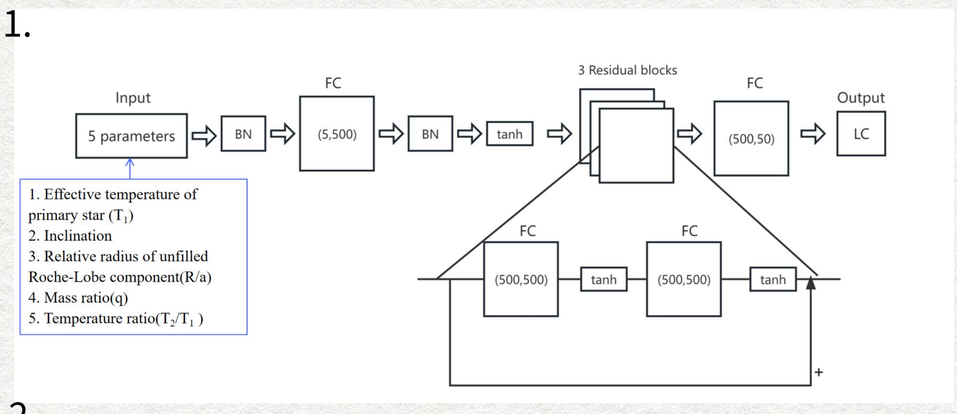
Backgound

Semi-detached binaries are in the mass transfer phase and play a crucial role in the study of mass transfer physics between interacting binaries. Large-scale time-domain photometric surveys (e.g. TESS, Kepler, ZTF, ASAS-SN) provide massive light curves of binary systems, while Gaia provides high-precision astrometric data. By combining these parameters and light curves, it is possible to construct a catalogue of complete parameters for semi-detached binaries. However, the widely used tools for analysing and fitting binary light curves, such as PHOEBE and WD, are time-consuming when dealing with large numbers of data points. Therefore, we develop a pipeline that combines the MCMC method with a machine learning model and DBSCAN clustering to search for semi-detached binaries and estimate their inclination, relative radius, mass ratio, and temperature ratio from the light curve.

Method

The mock light curves of semi-detached binaries generated by PHOEBE are used as a training set, and two light curve fitting models are trained using MLP (Fig.1). By combining the MCMC and DBSCAN methods, we designed the pipeline to find the best solution (Fig.2). The measurents are shown Fig.3.

1.



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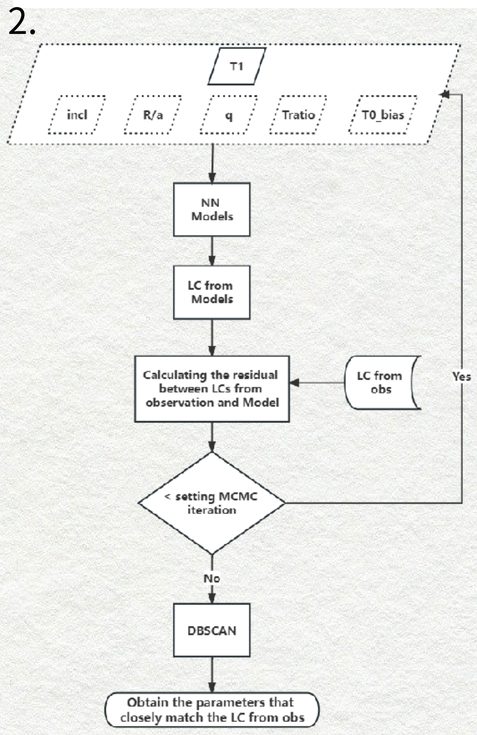

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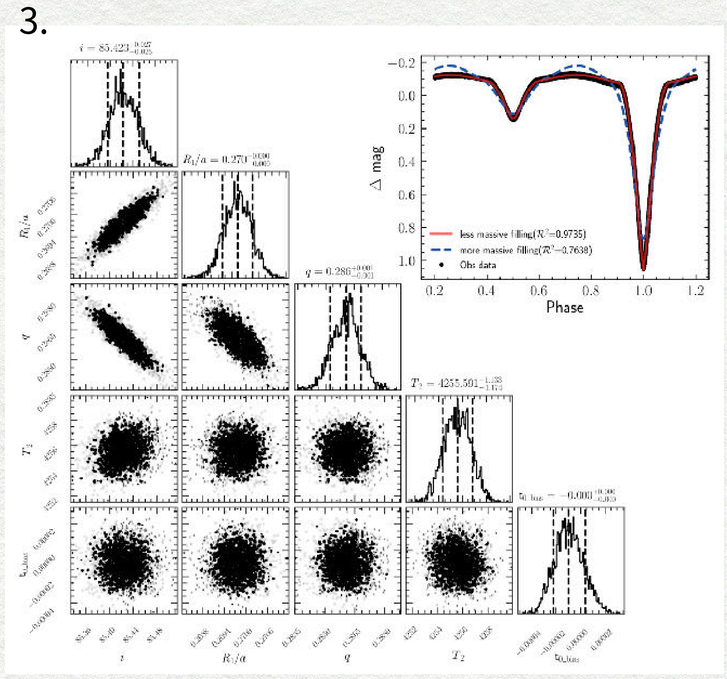
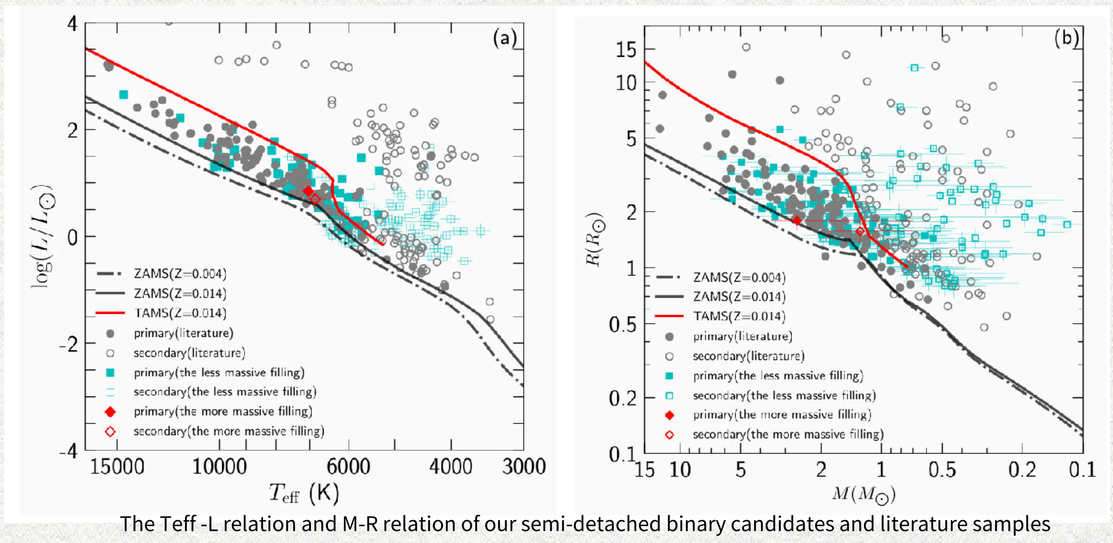


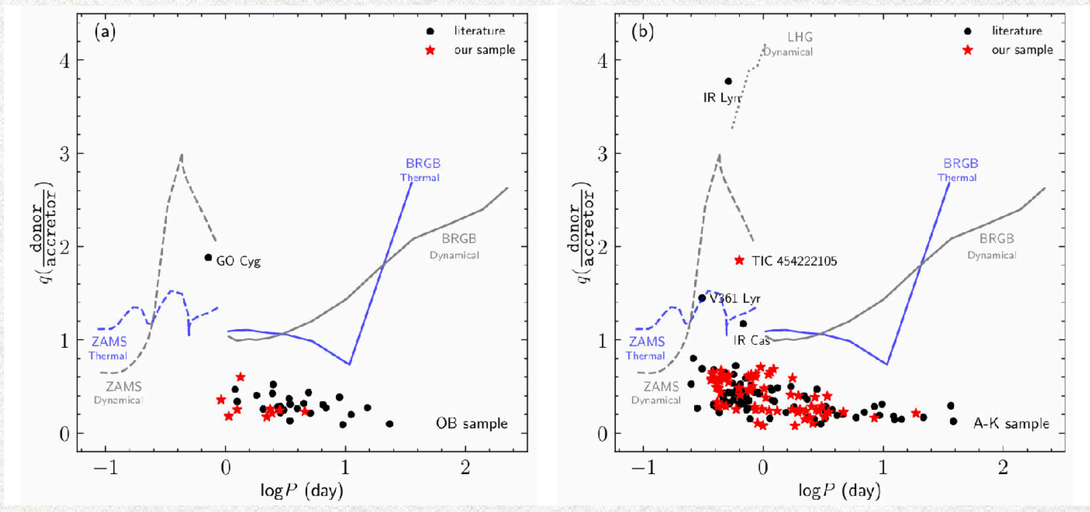
Results

77 semi-detached binary candidates are identified in TESS survey, including 76 binaries with a low-mass component filling its Roche lobe (cyan solid and open rectangles) and 1 system with a more massive star filling its Roche lobe(red solid and hollow diamond).



The Teff -L relation and M-R relation of our semi-detached binary candidates and literature samples

Most of these SD samples are below the critical mass ratio limit of BRGB for thermal timescales (solid blue lines), indicating nuclear timescale mass transfer. GO Cyg and TIC 454222105 are below the dynamical-timescale limit and above the thermal-timescale limit. It shows that these two samples are currently undergoing thermal-timescale mass transfer. IR Lyn is above the limit of dynamical-timescale mass transfer for LHG. It shows that this system is nearing the threshold for entering the dynamical timescale of mass transfer.



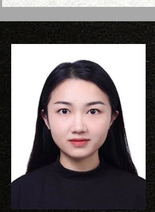
The distribution of mass ratio and orbital period for semi-detached binaries

Conclusions

1.We develop, validate, and apply a pipeline that combines the MCMC method with a forward model and DBSCAN clustering to search for SD binary and estimate their parameters using light curve.

2.With the added 77 candidates, the catalog of SD binaries with orbital parameters has been expanded by approximately 20%.

3.This pipeline can serve as a tool for analyzing SD binaries in other surveys.



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