Evolutionary status and spectral classification of selected neglected eclipsing binaries observed with Gaia and TESS

SLOVAK RESEARCH AND DEVELOPMENT AGENCY

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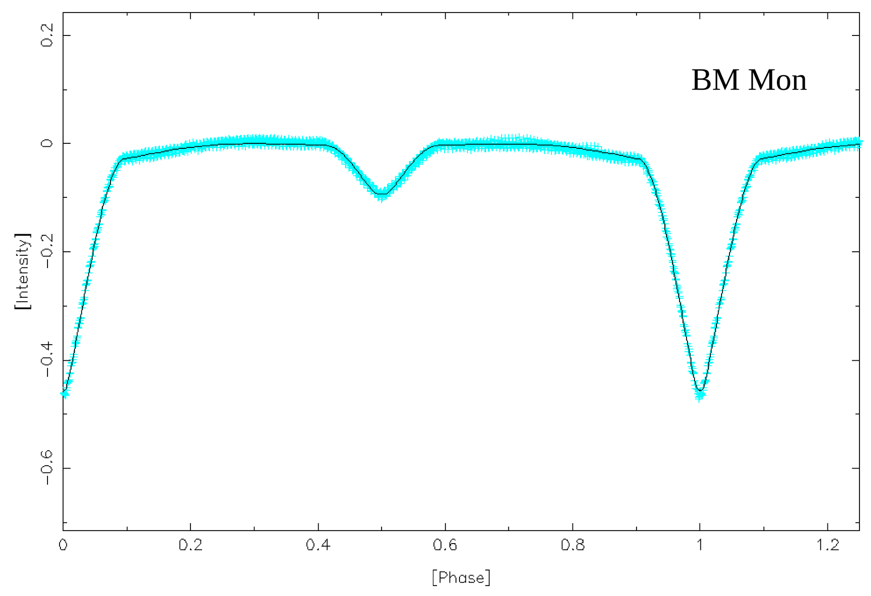
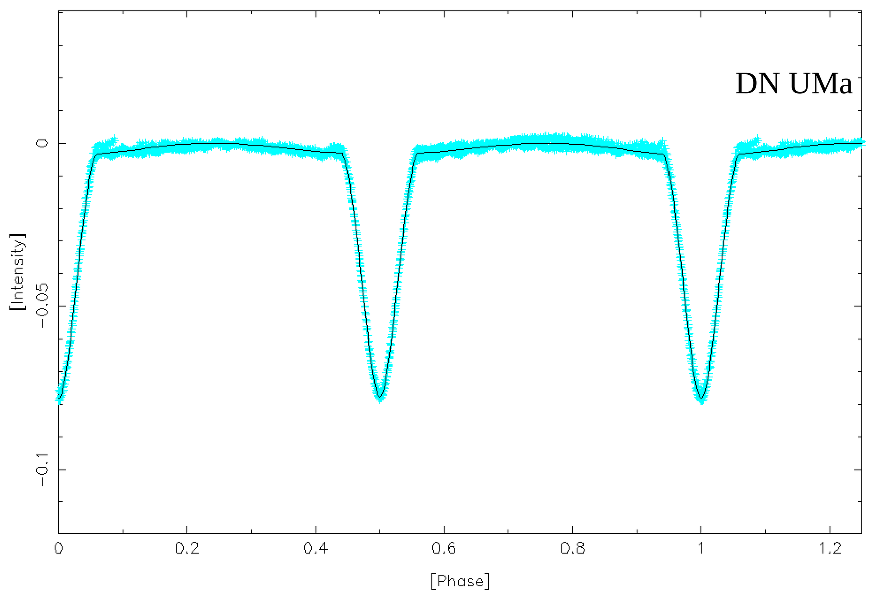
Many eclipsing binaries lack reliable classification and determination of their orbital elements and absolute parameters such as component masses, radii, and luminosities. Using a catalog of eclipsing binaries published by Avvakumova et al. (2013) about 250 relatively bright systems with unreliable and/or missing data were identified. To get the missing information, we have used the archival data generated by two space missions: *TESS* (Transiting Exoplanet Survey Satellite) and *Gaia.* The preliminary results and most interesting cases are presented and discussed.

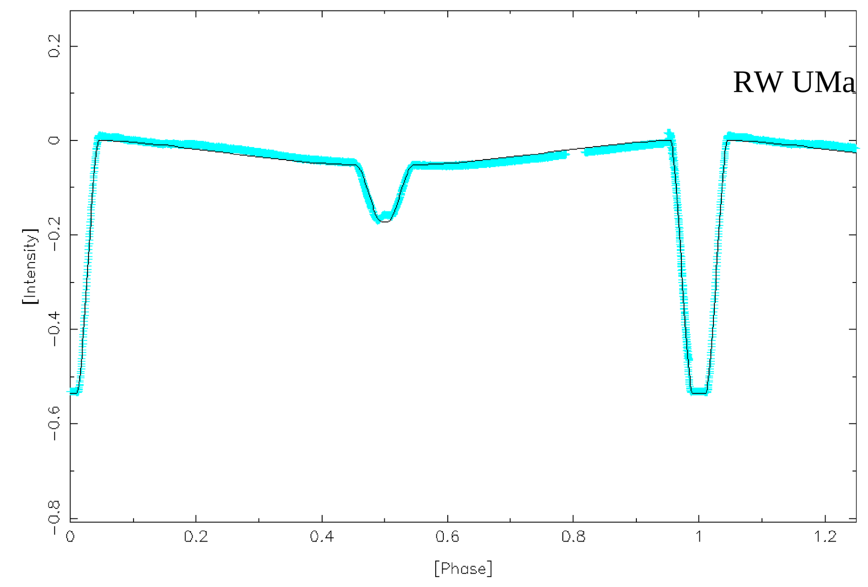
The TESS light curves were analyzed using code RMF (Roche ModiFied, see Garai et al., 2022), based on the ROCHE code (Pribulla 2012), which is devoted to the modeling of multi-dataset observations of close eclipsing binary stars. The software can simultaneously model multi-colour light curves, radial velocities, and broadening functions (or least-squares deconvolved line profiles) of binary stars and transiting exoplanets. The program uses simple spherical stars and the proximity effects are approximated analytically. This means much shorter runtimes than in the case of more realistic code ROCHE and a possibility to analyse large numbers of objects.



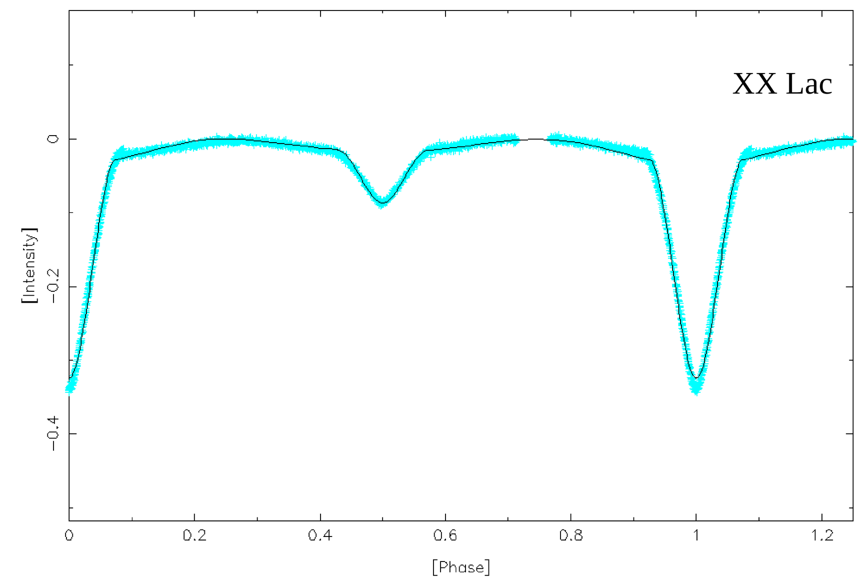
T_0 = 2459203.9951 ± 0.0022 [HJD]
P = 1.24484 ± 0.00065 days
i = 90.0±0.2 deg
r_{pri} = 0.2922±0.0015
r_{sec}/r_{pri} = 0.930±0.009
T_{sec} = 4291±3 K
l_3 = 0.76



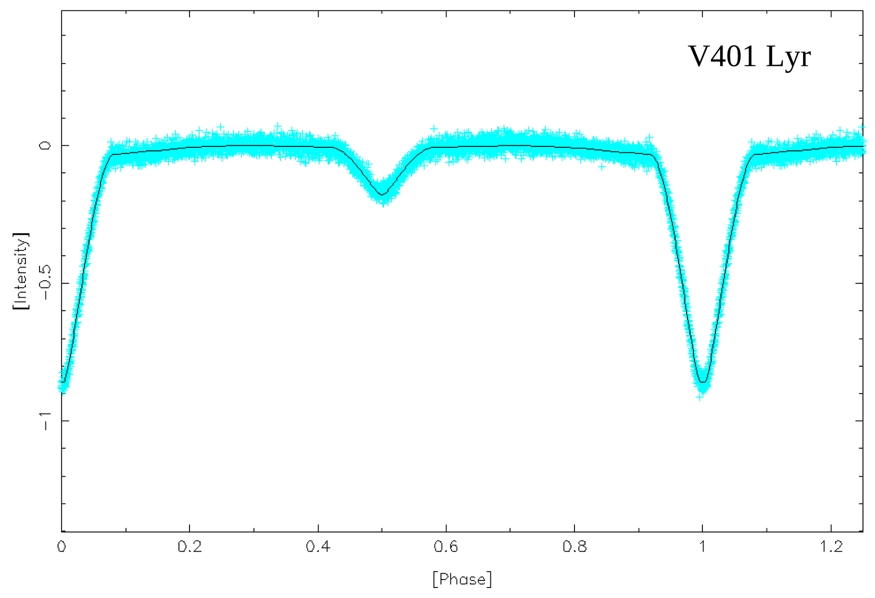
T_0 = 2460347.8484±0.0071 [HJD]
P = 1.73039±0.00042 days
i = 82.4±0.2 deg
r_{pri} = 0.1874±0.0050
r_{sec}/r_{pri} = 1.054±0.005
e = 0.00
T_{sec} = 9459±35 K
A_1 = 0.114±0.023
A_2 = 0.107±0.027
l_3 = 2.96



T_0 = 2460347.7711±0.0030 [HJD]
P = 7.34112±0.00061 days
i = 85.6±0.1 deg
r_{pri} = 0.0957±0.0033
r_{sec}/r_{pri} = 2.052±0.007
e = 0.00
T_{sec} = 9086±17 K
A_1 = 1.215±0.002
A_2 = 0.000



T_0 = 2459857.6794±0.0057 [HJD]
P = 4.06262±0.00081 days
i = 76.7±0.8 deg
r_{pri} = 0.2736±0.0083
r_{sec}/r_{pri} = 0.771±0.005
e = 0.00
T_{sec} = 3940±20 K
A_1 = 1.000
A_2 = 0.500



T_0 = 2453340.6169±0.0074 [HJD]
P = 1.31512±0.00015 days
i = 89.7±0.5 deg
r_{pri} = 0.2289±0.0043
r_{sec}/r_{pri} = 1.1092±0.0024
e = 0.00
T_{sec} = 4541±10 K
A_1 = 0.000
A_2 = 0.256±0.045

BM Mon is an eclipsing binary with a pulsating component. The *J-K* color index of the system 0.174±0.030 corresponds to the F0V spectral type for the primary component or T_{eff} = 7000 K. Our modeling uses 1547 LC points covering HJD from 2459201.74 to 2459212.51. A substantial third light was necessary to be added. Pulsations were assumed to average out and were not analyzed in detail. The geometric albedo of 0.5 was used for both components and a circular orbit was assumed. The resulting parameters indicate that the secondary component is oversized for its radius and hence the component parameters could be affected by the mass transfer.

DN UMa The *J-K* color index of 0.041±0.029 indicates the A2V spectral type for the primary component or T_{eff} = 8800 K. The TESS light curve shows that the system is a close binary with very similar components. The light-curve amplitude is substantially reduced by a bright visual companion of the 65 UMa system. Modeling uses 2740 LC points and covers HJD from 2460346.85 to 2460353.19. The light curve modeling confirms a large light contribution of other star entering the TESS aperture. To improve the out-of-eclipse parts of the light curve, we also adjusted the geometric albedo coefficients. This, however, resulted in small values of about 0.1.

RW UMa is a close but detached eclipsing binary. Modeling uses 3787 LC points and covers HJD from 2460345.80 to 2460355.0. The primary eclipse shows an interval of constant light indicating total eclipses in the system. This means that the hotter component in the system is also the smaller one. The out-of-eclipse light curve is strongly deformed, very probably by spot activity. This photometric wave can be modeled without surface inhomogeneities but non-physical values of the geometric albedo coefficients are necessary. Multi-color photometric data are necessary to reliably model the surface spots. The *J-K* color index of 0.553± 0.032 indicates K0V spectral type for the primary component or T_{eff} = 5240 K. This, however, corresponds to the combined color of the system which is composed of a smaller hot component and a larger cooler component. The larger cold component is, very probably, responsible for the photometric wave. The orbit seems to be circular. The system is relatively bright and should be easy to observe spectroscopically even with a meter-class telescope. The system very probably underwent a mass transfer.

XX Lac is a close detached eclipsing binary composed of a hotter primary and a colder secondary component. The light curve is symmetric and indicates a circular orbit for the system. Its infrared *J-K* color index is 0.352±0.037 corresponding to about F7V spectral type and effective temperature of 6240 K. Eclipses in the system seem to be partial. There was no need of a third light to fit the *TESS* observations properly. No significant light-curve asymmetries were recorded. Modeling uses 3905 LC points and covers HJD from 2459854.03 to 2459863.28.

V401 Lyr is another partially eclipsing binary with a circular orbit. The system is composed of a larger and hotter primary and a cooler and smaller secondary component. Its near infrared *J-K* index, 0.291±0.035, corresponds to about F5V classification or an effective temperature of 6530 K. The geometric albedo is far from acceptable values. No additional light was needed to properly fit the TESS light curve. It is interesting to note, that the cooler secondary component is slightly larger than the primary. Modeling uses 4998 LC points and covers HJD from 2460339.78 to 2460351.58.

This contribution shows preliminary analysis of several neglected eclipsing binaries published in the catalogue of Avvakumova et al. (2013). The main goal of the future work will be expand this study on determination of photometric elements for all neglected systems listed in the table „lack.dat“, published by Avvakumova et al. (2013) which have TESS photometry. Systems brigher than V = 11 will be observed spectroscopically using the 1.3m telescope of the Skalnaté Pleso observatory (see poster by T. Pribulla).

References:
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