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Exoplanets with Roman Surveys: Microlensing and Transits

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SETTING UP

A STRATEGY FOR TRIPLE-LENS MODELING

ANTONIO CONSIGLIO, V. BOZZA

DIPARTIMENTO DI FISICA "E.R. CAIANIELLO", UNIVERSITÀ DEGLI STUDI DI SALERNO, ITALY

Abstract

RTModel is a public Python library for modeling and interpretation of microlensing events.

It uses photometric and/or astrometric time series collected from ground and/or space telescopes to propose one or more possible models among the following:

- Single-lens-single-source
- Single-lens-binary-source

(with or without xallarap)

- Binary-lens-single-source

(including planetary microlensing, parallax and orbital motion)

- Triple-lens-single-source

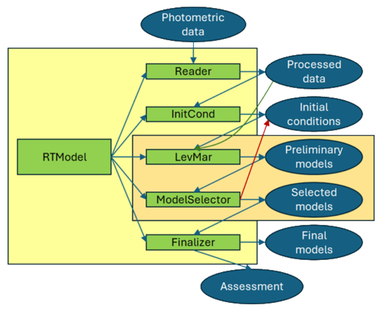
(including parallax and circular orbital motion)

All models include the finite-size of the source(s).

A strategy is being developed providing the initial conditions for fitting triple-lens systems. Therefore, in order to expand RTModel to the investigation of triple events, my work consists of introducing an anomaly detector and then, thanks to the use of analytical formulas, adding a planet so that the caustic creates a perturbation in the time of the anomaly. We will present some initial tests assessing the effectiveness of this strategy on multi-planetary microlensing events.

What is RTModel?

RTModel is a well-established platform for the real-time analysis and interpretation of microlensing events. It is a public Python library calling C++ subprograms, each of which performs a specific task with the aim of providing the best model that represents the microlensing event in question.



The subprograms are:

Reader: data pre-processing, including cutting unneeded baseline, re-binning, re-normalization of the error bars and rejection of outliers.

InitCond: initial condition setting.

LevMar: fitting models from specific initial conditions by the Levenberg-Marquardt algorithm.

ModelSelector: selection of the best models and removal of duplicates.

Finalizer: interpretation of the microlensing event obtained.

Model categories

The choice of models in RTModel includes several options.

Single-lens with a single or binary source or binary-lens with a single source events and triple-lens with single source and in each case static or parallax models are considered providing the initial conditions.

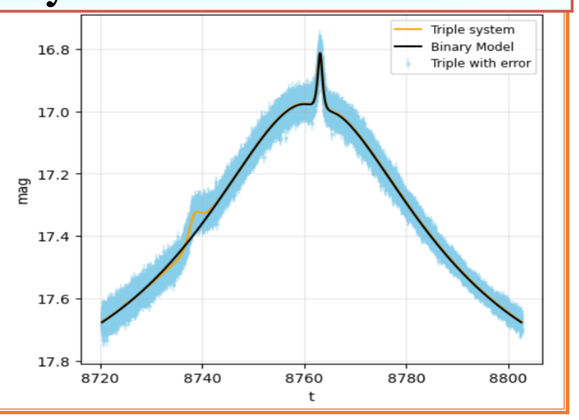
Label	Model
PS	Single-lens-single-source
PX	Single-lens-single-source with parallax
BS	Single-lens-binary-source
BO	Single-lens-binary-source with xallarap
LS	Binary-lens-single-source
LX	Binary-lens-single-source with parallax
LO	Binary-lens-single-source with circular orbital motion
LK	Binary-lens-single-source with eccentric orbital motion
TS	Triple-lens-single-source
TX	Triple-lens-single-source with parallax
TO	Triple-lens-single-source with circular orbital motions

Triple Lens model

A strategy is being developed providing the initial conditions for fitting triple-lens systems.

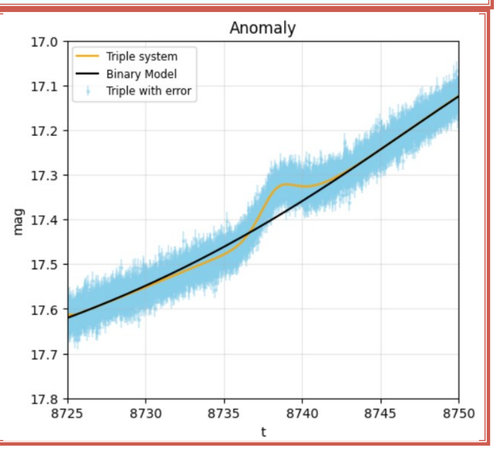
Fitting binary-lens model

We follow the RTModel strategy and select the best binary-lens model to the data.



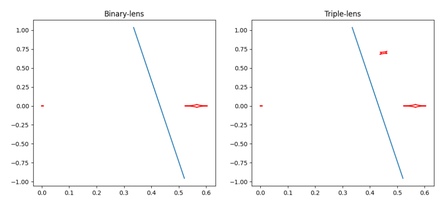
My work

My work consists in the introduction of an anomaly detector and then, starting from the binary lens model and by the use of analytical formulas, it is possible to add a planet so that the caustic creates a perturbation at the time of the anomaly.



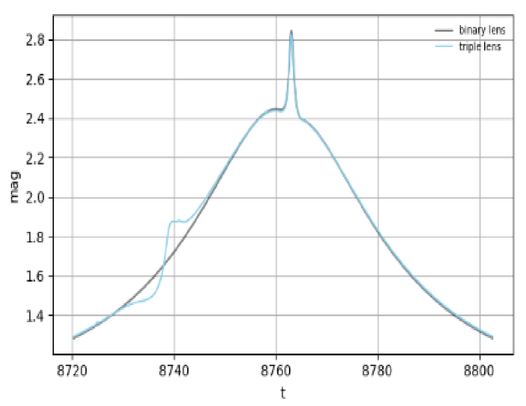
The new peak in the light curve comes from the addition of the third planet.

The new generated model provides an initial condition for fitting a triple-lens model with two planets.



Taking the initial conditions obtained from the fit, we obtain the following triple-lens model.

s	1.1913693743
q	0.0005128017
u0	0.4768875822
alpha	1.6610890273
rho	0.00001013
tE	38.544326156
t0	8761.41
s2	0.7104341633
q2	0.001
beta	4.2048962775



This strategy can be extended to find multiplanetary system in Roman data.

References

Bozza V., 2024. RTModel: A platform for real-time modeling and massive analyses of microlensing events, A&A, 688, A83 (2024)

CONTACT
Antonio Consiglio
aconsiglio@unisa.it
@_antoconsy76

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