Considerations and Design Principles for the 2.1 Release of the PHOEBE Eclipsing Binary Modeling Code

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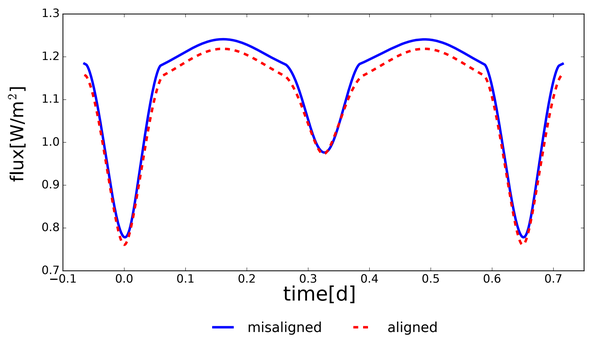
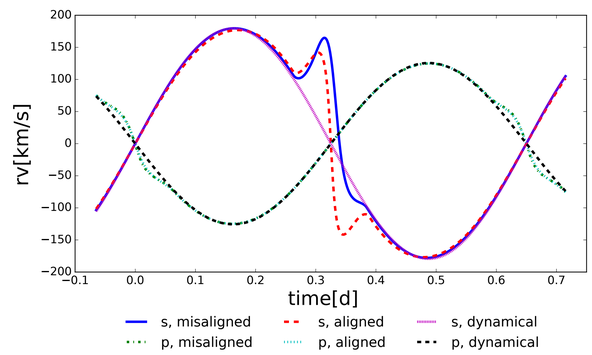
PHOEBE 2.0 (http://phoebe-project.org) was released in early 2017 (Prša et al, 2016), introducing the next-generation of modeling eclipsing systems with increased precision, triangulated meshing, light travel time effects, Doppler boosting, and improved atmospheric and passband treatments. The recent 2.1 release builds upon this with support for misalignment between the rotational and orbital axes, built-in MPI parallelization, as well as support for creating synthetic spectral line profiles. Here we discuss the implementation and use cases of these new features as well as the parameterization change from polar to equivalent radius and redesign of the plotting framework made between the 2.0 and 2.1 releases of PHOEBE.

Misalignment



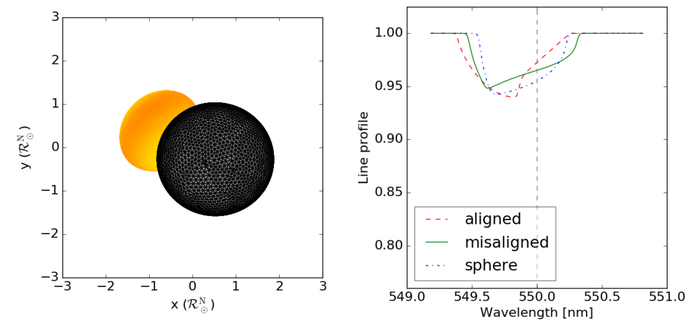


Spin-orbit misalignment can significantly affect observables (light curves, radial velocity curves, etc), but is not included in the classical Roche framework.

The analytical formalism for binary systems with misaligned rotational and orbital angular velocity vectors has been discussed previously by Limber (1963); Kruszewski (1966); Avni & Schiller (1982). It was not until now, however, that this effect has been built into an eclipsing binary (EB) modeling code, although a few works (Winn et al. 2006; Albrecht et al. 2012; Triaud et al. 2013; Harding et al. 2013) do use the anomalous Rossiter-McLaughlin Effect to measure obliquity.

In PHOEBE 2.1, this misalignment is parameterized on the plane-of-sky as a misalignment in inclination and longitude of the ascending node, relative to the orbit.

Spectral Line Profiles



PHOEBE 2.1 introduces the support for spectral line profiles as an observable (in addition to light curves, radial velocity curves, and orbits supported in 2.0). These can be computed and exposed at any given time(s) and for the composite system as a whole, or inidividual sub-components.

Internally, profiles are computed as a weighted sum of Doppler-shifted Gaussian or Lorentzian profiles around a provided rest wavelength.

Equivalent Radii

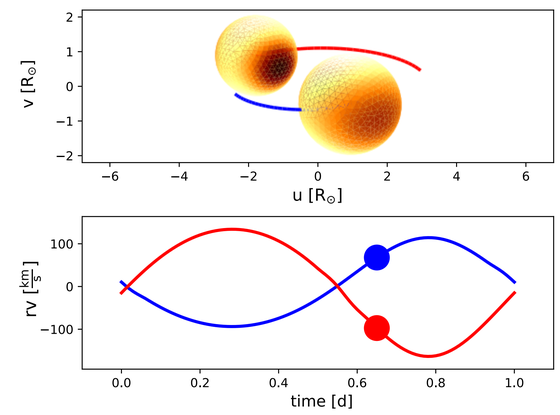
The introduction of misalignment made a change from polar radius or surface potential to equivalent radius necessary. In PHOEBE 2.0, it was possible to set either the polar radius or the surface potential, with the polar radius kept fixed when using non-Roche geometries. This flexibility resulted in confusing and unclear behavior when extended to misaligned systems. So, in PHOEBE 2.1, the polar radius is replaced by the equivalent (volumetric) radius, which will be conserved for any change in misalignment parameters or distortion methods.

Convenience functions are available for users wishing to import systems defined with polar radius and/or surface potential.

Parallelization

PHOEBE 2.1 also introduces built-in support for parallelization via MPI. By default, PHOEBE will automatically split the computing task among the available processors per-timestamp after completing all initial setup computations. However, advanced MPI setups are also possible by disabling PHOEBE's internal parallelization and managing the processors manually.

Plotting



PHOEBE 2.1 also comes packaged with a brand-new plotting interface as a frontend to matplotlib. This plotting frontend, called autofig, allows for creating advanced figures and animations with minimal scripting, while still allowing customization via access to the underlying matplotlib objects. Autofig allows for:

* intelligent defaults for axes limits,
* animating over any independent variable,
* linked colormapping between different plot calls,
* single interface to multiple mpl calling structures.

Autofig is available externally from PHOEBE and is also open-source at github.com/kecnry/autofig.

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Try PHOEBE 2.1

phoebe-project.org/2.1

phoebe-project.org/quickstart

github.com/phoebe-project/phoebe2

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