Validation of binary and multiple star systems from Gaia with SOPHIE

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Since 2019, we are performing, with SOPHIE, a spectroscopic follow-up of stars detected by Gaia as binary and multiple systems in order to validate the orbital solutions produced by the Gaia pipelines (Gaia Collaboration et al. 2023).

There are in fact important artefacts in the Gaia data, which are difficult to mitigate. For what concerns the astrometry, the Gaia instrumental calibrations are not optimal for bright stars, and partially resolved sources produce spurious signals (in both Gaia astrometry and spectroscopy, see Holl et al. 2023 for details). For the Gaia RVS (Cropper et al. 2018), spurious radial velocities variations can be induced by light contamination from nearby bright stars, given the lack of a slit in the instrument (e.g. Boubert et al. 2019). Moreover, the limited spectral resolution of the RVS undermines the measure of the radial velocities in SB2, if the source is not bright and the velocity separation large. Finally, RVS is limited by its very small wavelength range.

These effects were found to generate fake orbital solutions which end up in the Gaia releases. In order to reduce the number of published spurious binary solutions, the Gaia DPAC had to adopt drastic filtering, at the expense of discarding many *bona fide* binaries. Spectroscopic observations with a high resolution and high radial velocity precision spectrometer like SOPHIE provide crucial information in order to improve the understanding of Gaia's instrumental artefacts and the filtering strategy in the Gaia pipeline.

In our SOPHIE programs we looked at:

- Systems with large mass functions: such orbital solutions are easily produced by instrumental artefacts while the real systems (hosting neutron stars or black holes) are rare in Nature. An example of a system hosting a BH confirmed by SOPHIE is Gaia BH3 (Gaia Collaboration et al. 2024), the largest stellar BH discovered so far in our Galaxy.
- Systems with small mass functions: these systems can host a substellar component or being due to a binary with same luminosity components.
- System for which Gaia astrometry and spectroscopy give inconsistent orbital solutions.

In this talk we will describe some of these examples and show how SOPHIE observations helped us to understand the nature of the observed sources.

References

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