Optimizing SOPHIE data reduction software

A highly precise data reduction system is essential in radial velocity (RV) measurements to detect low-mass planets and address the possible sources of error. In this presentation, I will highlight the results of my Ph.D. study on troubleshooting and enhancing the SOPHIE Data Reduction Software (DRS) to overcome instrumental limitations. The study focused on adding new features to the DRS including atmospheric dispersion effect correction, fixing the number of mask lines at different epochs, optimizing long-term variation from the zero-point, optimizing conditions for detecting solar contamination spectra, and correcting background contamination from calibration lamps. The addition of these improvements has significantly enhanced SOPHIE's planet detection limit. Remarkably, it substantially improved the RMS of the FWHM SOPHIE activity indicator by 18.57 m/s, resulting in FWHM being used to trace stellar activity more reliably. I will demonstrate in several examples, these improvements enhanced data accuracy and interpretation, leading to a promising outlook on prospective discoveries from archived data. Some of those improvements could be relevant and adapted for other high-precision spectrographs such as Neo-NARVAL, SPIRou, HARPS, and ESPRESSO. This work plays a significant role in the precise detection and in-depth characterization of current and upcoming planets detection by SOPHIE, and consequently in the preparation and exploitation of exoplanet missions like PLATO.