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PAOS, the Physical Optics Propagation model of the Ariel optical system

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Ariel, the Atmospheric Remote-sensing Infrared Exoplanet Large-survey, is a medium-class space mission part of ESA's Cosmic Vision programme, due for launch in 2029. Ariel will survey a diverse sample of about 1000 extrasolar planets in the visible and infrared spectrum to answer questions about their composition, formation and evolution. Ariel mounts an off-axis Cassegrain telescope with an 1100 mm x 730 mm elliptical mirror and has two separate instruments (FGS and AIRS) that cover the 0.5-7.8 micron spectral range. To study the Ariel optical performance and related systematics, we developed PAOS, the Physical Ariel Optics Simulator, an End-to-End physical optics propagation model of the Ariel Telescope and subsystems. PAOS is a Python code that consists of a series of functions and procedures that reproduces the Ariel optical design. Using PAOS, we can investigate how diffraction affects the electromagnetic wavefront as it travels through the Ariel optical systems and the resulting PSFs in the photometric and spectroscopic channels of the mission. This enables to perform a large number of detailed analyses, both on the instrument side and on the optimisation of the Ariel mission. In particular, PAOS can be used to support the requirement on the maximum amplitude of the aberrations for the manufacturing of the Ariel primary mirror, as well as to develop strategies for in-flight calibration, e.g. focussing procedures for the FGS and AIRS focal planes, and to tackle systematics such as pointing jitter and vignetting. With the Ariel mission now in the process of finalizing the instrument design and the data analysis techniques, PAOS will greatly contribute in evaluating the Ariel payload performance with models to be included in the existing Ariel simulators such as ArielRad, the Ariel Radiometric model, and ExoSim, the Exoplanet Observation simulator, for the purpose of studying and optimising the science return from Ariel.