From disk to dust : The new DRAGyS tool for extracting scattering phase function through disk observation

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The early phase of planet formation, involving the birth of planetesimals through grain growth, remains one of the most enigmatic chapters in the story of planetary systems. Estimating the dust grain properties in these young disks is a key requirement for studying dust evolution. Recent studies of the scattering phase function (SPF) measured in the disks surrounding young stars may reveal crucial insights on dust grain properties. However, with the growing number of high-resolution disk images, there is a pressing need for a fast and scalable analysis tool.

This is the starting point for `DRAGyS` (Disk Ring Adjusted Geometry yields Scattering phase function). `DRAGyS` is a new tool designed for fast, model-free estimation of disk geometry and extraction of the total and polarized SPF in protoplanetary disks with rings and gaps. `DRAGyS` directly estimates key parameters — inclination, position angle, and scattering height — by fitting ellipses to surface brightness peaks, assuming circular disks and without the need for time-consuming radiative transfer modeling. We tested and validated our method both on synthetic disk images and on a sample of nine archival VLT/SPHERE images of polarized scattered light from six protoplanetary disks. Beyond its time-saving method, `DRAGyS` stands out for its ability to extract the SPF separately from each side of the disk, making it particularly suited to the study of asymmetries. More importantly, it incorporates a correction for limb brightening, a geometric effect largely neglected in previous studies but which significantly alters the SPF, particularly at smaller scattering angles. `DRAGyS` accurately recovers geometric parameters from synthetic data and provides SPFs in excellent agreement with the results of previous published research. Its key advantages lie in its quick, purely geometric approach to estimating the disk geometry and extracting the SPF, either globally or by disk side, making it a powerful tool for the analysis of ring-shaped protoplanetary disks.

Furthermore, we apply DRAGyS to a promising sample: a set of protoplanetary disk images from the large program DESTINYS, observed with VLT/SPHERE in the J, H, and K bands. Among these observations, a dozen disks reveal well-marked ring structures, perfectly suited to analysis with `DRAGyS`. This panel represents a new application for our tool, both in terms of statistical analysis of SPFs over the whole set of disks, and in terms of specific studies of remarkable cases, some of which have several rings or have been observed at different wavelengths. We will present the preliminary results and trends on dust properties provided by the SPFs from this large sample. This represents a key step forward in constraining dust evolution.