Training Opportunity for Irish Trainees

Reference	Title	Duty Station
IE-2018-SCI-OOO	**Gaia bright stars data processing and analysis**	**ESAC**

Overview of the unit's mission:

The Gaia mission is creating a complete astrometric survey of all stars within the magnitude range G = 3.0 - 20.0. They are selected and observed autonomously by the spacecraft. Several pipelines are processing all the data downlinked. In addition to regular data acquisition, special techniques are used to acquire additional data for bright stars that would not be observed otherwise, i.e. targeted sky mapper full frames and VO-sync observations for selected objects are acquired. The list currently comprises all stars brighter than G = 3.0 and G=1.75, for each technique respectively. Those data acquisition address the scientific need of making Gaia complete in the bright end.

Overview of the field of activity proposed:

Science case

The Gaia mission requires completeness in the bright end down to G = 6.0, which excludes all naked-eye stars, comprising ≈5000 objects. These stars are fundamental benchmarks for stellar astrophysics, because they can be studied in most detail. Sahlmann et al. (2016, Proc. SPIE 9904E 2ES) highlighted a few science cases where they play a prominent role:

1. Accurate masses of known exoplanets. Solar and later spectral type bright stars have extensively been studied with radial velocities, which only provide projected masses. Gaia astrometry could potentially determine accurate masses for ≈40 exoplanets.
2. Discovering new exoplanets around very bright stars. This sample has been studied with radial velocities, but many stars have been excluded due to high rotational velocities or activity. A significant impact is expected for A and F stars, reaching tens of new planets.
3. Parallaxes and proper motions of very bright stars. An improvement of an order of magnitude in distances and luminosities is expected as compared to Hipparcos. Objects with astrometric acceleration compatible with wide binaries would be ideal targets for direct imaging follow up with e.g. Gemini/GPI, VLT/SPHERE.or JWST/NIRISS.
4. Binary stars. Hipparcos revealed a non-standard astrometric behaviour for ≈25% of this sample, about half of them being binaries. The Gaia increased precision would provide additional insight, and explore larger primary-to-secondary mass ratios.

Technical background

Martín-Fleitas et al. (2014. Proc. SPIE 9143E 0YM) and Sahlmann et al. (2016) have shown the on-board detection system proved far more capable than specified, achieving completeness down to G ≈ 2.0, after optimising the algorithm following SOC recommendations.

In addition, the ≈50 brightest objects can be observed using two techniques: SIF imaging and VO sync. The former records portions of the Sky Mapper video, providing full-frame high signal to noise stellar images for the first CCD. The latter places (Virtual Object) windows synchronised in time and angle with the observation of bright stars. This is possible to the superb stability of Gaia, which allows predictions with ms (time) and arcsec (angle) precision covering several months.

VO sync has the potential to obtain accurate spectrophotometry of Vega, the primary photometric standard, with enormous implications for the Gaia absolute flux calibration.

Work plan

- Analysis, validation and optimisation of the performance of VBS centroiding on nominal Gaia data from the standard data processing pipeline. In addition, extension of the optimised centroiding scheme to non-nominal Gaia data.
- PSF fitting to the SIF SM and VO sync AF data. Gaia routine PSF calibrations will be used for the latter, while ad-hoc models are needed for the SM data.
- Spectrophotometry fundamental reference stars such as Vega and Sirius. Note significant core saturation is observed both in the spectra and stellar images.
- Preparation of the astrometric solution and an exploration of how to obtain an AGIS secondary star solution.

Required education:

Master's degree in science or engineering discipline