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Gaia Reference Frame Determination: the AVU/GSR Pipeline

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Abstract

Abstract The main goal of the Gaia ESA mission is the production of a 5 parameters astrometric catalog - i.e. including positions, parallaxes and the two components of the proper motions - of about 1 billion stars of our Galaxy at an accuracy level going from around $10 \mu\text{as}$ at the bright end and a few $100 \mu\text{as}$ at the faint end of the objects' sample. This goal is reached by means of high-precision astrometric measurements conducted by a satellite sweeping continuously the celestial sphere during its 5-years mission. A fundamental step toward the realization of this catalog is the so-called "Sphere Reconstruction", which determines the celestial reference frame using the observations of a subset of up to 100 million "primary stars" among those observed by Gaia. From a mathematical point of view, these observations translate into a large number of equations, linearized with respect to the unknown parameters around known initial values, whose solution in the least-squares sense eventually provides the catalog with its errors, and determines the Gaia reference frame. This represents an extremely challenging problem because of the high quality of the observations and the large number of unknowns involved. The former issue implies that an adequately accurate relativistic astrometric model has to be used, while the huge number of unknowns and observations puts this task at the forefront of High-Performance Computing problems. These challenges, and the absolute character of the Gaia measurements, call for a careful scientific validation of the sphere reconstruction. For these reasons the Gaia Data Processing and Analysis Consortium (DPAC) decided to replicate the baseline process, named AGIS (Astrometric Global Iterative Solution) with another independent solution: this is implemented in GSR, the Global Sphere Reconstruction, that uses different astrometric models and different algorithms for accomplishing the reconstruction of the Gaia reference frame and compare to AGIS.