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ORIGINAL ARTICLE

Building the cosmic distance scale: from Hipparcos to Gaia

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Abstract Hipparcos, the first ever experiment of global astrometry, was launched by ESA (European Space Agency) in 1989 and its results published in 1997 (Perryman et al. in Astron. Astrophys. 323:L49, 1997; Perryman & ESA (eds.) in The Hipparcos and Tycho catalogues, ESA SP-1200, 1997). A new reduction was later performed using an improved satellite attitude reconstruction leading to an improved accuracy for stars brighter than 9th magnitude (van Leeuwen & Fantino in Astron. Astrophys. 439:791, 2005; van Leeuwen in Astron. Astrophys. 474:653, 2007a). The Hipparcos Catalogue provided an extended dataset of very accurate astrometric data (positions, trigonometric parallaxes and proper motions), enlarging by two orders of magnitude the quantity and quality of distance determinations and luminosity calibrations. The availability of more than 20 000 stars (22 000 for the original catalogue, 30 000 for the re-reduction) with a trigonometric parallax known to better than 10% opened the way to a drastic revision of our 3-D knowledge of the solar neighbourhood and to a renewal of the calibration of many distance indicators and age estimations. The prospects opened by Gaia, the next ESA cornerstone, planned for launch in 2013 (Perryman et al., in Astron. Astrophys. 369:339, 2001), are still much more dramatic: a billion objects with systematic and quasi simultaneous astrometric, spectrophotometric and spectroscopic observations, about 150 million stars with expected distances to better than 10%, all over the Galaxy. All stellar distance indicators, in very large numbers, will be directly measured, providing a direct calibration of their luminosity and making possible detailed studies of the impacts of various effects linked to chemical element abundances, age or cluster membership. With the help of simulations of the data expected from Gaia, obtained from the mission simulator developed by DPAC (Gaia Data Processing and Analysis Consortium), we will illustrate what Gaia can provide with some selected examples.

Keywords Space observatory · Astrometry · Hipparcos · Gaia · Stars: distances · Stars: fundamental parameters · Star clusters · Pulsating variable stars · Distance scale

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1 Introduction

The last 15 years have seen some major improvements in the determination of the fundamental distance scale, due mainly to three factors: the first ever availability of a large number of precise trigonometric parallaxes from Hipparcos, a big effort in obtaining spectroscopic and photometric observations of various stellar candles to study the effects of colour, metallicity, age, cluster membership, etc. on the absolute luminosity and, finally, the observation of further and further stellar candles in external resolved galaxies with the Hubble Space Telescope and with large telescopes on the ground.

However, even though Hipparcos was a major improvement with respect to earlier ground-based astrometric observations, *only* about 30 000 stars (compared to a few hundreds before it) were observed with a relative accuracy