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GAIA: STELLAR PHYSICS AND CHARACTERIZATION OF HOST STARS

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Abstract. The *Gaia* satellite measures parallaxes, proper motions, the photometry of more than 1 billion stars, and the radial velocities for 150 million of them, as well as the atmospheric parameters for the brightest. With precise parallaxes better than 1% for 10 million stars, *Gaia* reveals the fine structure of the HR diagram for all stellar populations and all phases of star evolution. Completed with the results of asteroseismology, measurements of angular diameters, ground spectroscopic readings, this very high quality data set allows to constrain the models of internal structure, evolution, and atmosphere of the stars, for stellar physics in general, with strong implications for the characterization of host stars and exoplanets.

Keywords: *Gaia*, Stars: physics, Stars: stellar systems

1 Gaia in a nutshell

The *Gaia* mission (Gaia Collaboration et al. 2016) provides full sky coverage down to the *Gaia* magnitude G = 20 (V$\simeq$20-22), at the spatial resolution of the HST, with about 70 observations per source over 5 years. It performs micro-arcsecond global astrometry for all stars down to G = 20. Parallaxes and proper motions are today measured for these 1.3 billions stars, and published in the *Gaia* DR2 catalogue (see Fig. 1, Gaia Collaboration et al. 2018b).

Gaia will also observe millions of galaxies, $\sim$ 500 000 quasars that will help to refine the celestial reference frame. Thanks to the time sampling and high photometric precision (at the level of the milli-magnitude), variable stars can be carefully studied and new microlenses are found from the light curve. Alerts are given for transient phenomena, allowing the follow-up of events such as the discovery of supernovae.

Moreover, $\sim$100 000 new solar system objects are expected to be found, as well as $\sim$10 000 exoplanets, up to a distance of 500 pc.

Fig. 2 illustrates the path towards the final *Gaia* catalogue. The basic catalogue content is:

- from the astrometry: α, δ, parallax, μ_α, μ_δ, and binaries with orbital solutions when possible;
- from the photometry: multi-epoch magnitudes in the *Gaia* passbands (G, G_{BP},G_{RP},G_{RVS}, extinction, effective temperature, gravity, [M/H] and [α/Fe] (for bright stars), luminosity, mass, age;
- from spectroscopy: radial velocities (to G<17, $\sim$150 million stars), rotational velocities, atmospheric parameters, interstellar reddening (to G<12, $\sim$5 million stars)), abundances (to G<11, $\sim$2 million stars);
- and also: object classification, variable star classification, period, amplitude, extended objects classification, etc.

The very high performances of *Gaia* are given in the *Gaia* website*.

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* `https://www.cosmos.esa.int/web/gaia/science-performance`

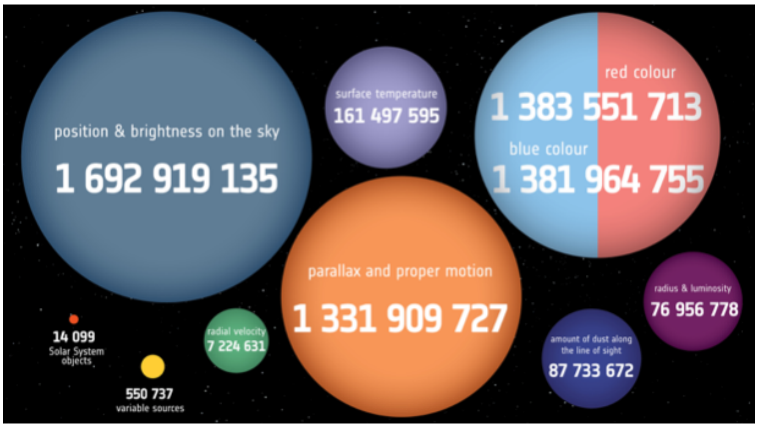

Fig. 1. The second data release (*Gaia* DR2) content. Credit: ESA.

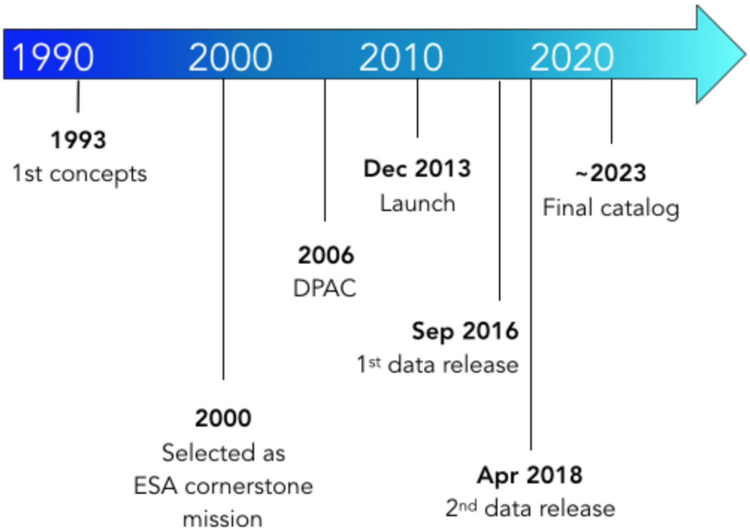

Fig. 2. The *Gaia* mission timeline.

2 Gaia and stellar physics

Thanks to the very high astrometric performances, distances will be measured, at the end of the mission, at 1% for $\sim$ 1 million of stars up to 2.5 kpc, and at 10% for $\sim$ 10 millions of stars up to 25 kpc. The precision, accuracy, and homogeneity of both astrometry and photometry and makes possible the construction of an unprecedented Hertzsprung-Russel diagram (Gaia Collaboration et al. 2018a).

It allows to derive accurate luminosity calibrations, in particular for cosmic candles. Given the large number of measured stars, fundamental parameters of rare stars (eg stars at rapidly evolving stage) will be derived. Accurate luminosity complemented with effective temperature provides radius of stars in the whole Hertzsprung-

Russel diagram. This data set is unique to test stellar models (evolution, interior) for all kind of stars.

3 Gaia and exoplanets

About 10 000 long-period planets of 1 to 15 Jupiter mass, up to 500 pc, are expected to be discovered by *Gaia* by measuring the wobble they cause in the path followed by their parent stars on the sky.

Although the *Gaia* scanning law was not optimised for detecting transiting planets, these type of events can be seen in the *Gaia* data as well (see eg the known transiting planets WASP 19B and WASP 98B observed by Gaia during the mission's first year[†]. The full set of data from the five-year nominal mission might serve as an all-sky survey for transiting exoplanets.

4 Conclusions

The *Gaia* mission provide an all-sky catalogue with very high precision for any type of stars. Beside the indirect detection of exoplanets (from astrometry and transits), *Gaia* will provide unprecedented data to characterize the parent stars.

The astrometry and photometry can be used to get stellar radii and thereby to have better estimates of planet radii, in particular for the numerous *Kepler* planets.

The *Gaia*-based stellar age estimates can be used to compare planetary systems around stars of different ages, to compare ages of planetary systems with different architectures, to study the dynamical evolution of stellar system via the relation between eccentricities and stellar ages.

Furthermore, *Gaia* or complementary ground-based data such as the future spectroscopic surveys (eg WEAVE, Dalton et al. (2014), 4MOST, de Jong et al. (2016)) could detect signatures of stars that have recently accreted their planets, and therefore detect different signatures on different time-scales.

References

Dalton, G., Trager, S., Abrams, D. C., et al. 2014, in Proc. SPIE, Vol. 9147, Ground-based and Airborne Instrumentation for Astronomy V, 91470L

de Jong, R. S., Barden, S. C., Bellido-Tirado, O., et al. 2016, in Proc. SPIE, Vol. 9908, Ground-based and Airborne Instrumentation for Astronomy VI, 99081O

Gaia Collaboration, Babusiaux, C., van Leeuwen, F., et al. 2018a, A&A, 616, A10

Gaia Collaboration, Brown, A. G. A., Vallenari, A., et al. 2018b, A&A, 616, A1

Gaia Collaboration, Prusti, T., de Bruijne, J. H. J., et al. 2016, A&A, 595, A1

[†] `https://www.cosmos.esa.int/web/gaia/iow_20170209`