Foreword

Binary and multiple systems are ubiquitous in the Universe and their orbits indeed offer the best way to estimate the component masses. Their prediction, discovery, observation and analysis are part of the history of science as well as foremost current research activities. Orbits of visual binaries were computed for the first time at the middle of the XIXth century; spectroscopic binaries and eclipsing binaries were discovered by the end of that century; and one century later, the first exoplanets and the first binary asteroids were discovered. Although, at first sight, there seems to be a rather weak connection between the scientific problems related to multiple stars, exoplanets, and Solar System objects, the problem of orbit determination actually appears as a common concern among the various communities involved in studying these different astronomical objects.

Over the time, many orbit determination methods have thus been — and are still being — developed, not simply due to the various dimensions of the data (astrometric, photometric, spectroscopic, light-travel time, etc.). Still, a small number of masses only are available. In this respect, the advent of the Gaia survey will bring a considerable quantitative change as hundreds of binary asteroids, thousands of exoplanets or millions of stellar binaries are expected to be observed.

Let us start with few words about Gaia. As an all-sky astrometric — but also photometric and spectroscopic — survey, Gaia is expected to provide phase space parameters for about one billion stars and hundreds of thousands of asteroids, and it will also give fundamental astrophysical information for a very large fraction of these: object masses and formation characteristics are one of the very important outcomes of the mission. As a side effect, the considerable size of these samples implies that the processing of the Gaia data requires non-artisanal methods. Also, the scientific content, and possibly biases, will be statistical by nature, and a very large improvement is expected to come through the combination of the intermediate Gaia data with complementary high precision external data. This would improve the orbital elements and allow better mass estimations — but it will not always be that obvious.

It happens that the Data Processing and Analysis Consortium (DPAC) — the European group in charge of the Gaia data processing — mix up rather artificially in a single structure, the CU4 Coordination Unit, the data processing for everything that is not a single stars. Scientist from the solar system field are side by side with binary stars or exoplanet specialists, with a friendly though mostly not scientific communication between groups. It was however recently realised that these groups could very usefully share their expertise about one common problem, the determination of orbits, masses, and other parameters characterising systems gravitationally bound, and this gave birth to the idea of this joint workshop.

In line with the GREAT/ESF objectives, the rationale of the workshop has been to draw the attention of the astronomical community to the Gaia outcome, bringing together the various scientific expertise, a cross-fertilization potentially permitting to improve the methods and techniques and consequently the astrophysical gain with Gaia. The workshop was hosted by the Observatoire de Paris and there was after all some logic in that: not simply due to its large involvement in Gaia, but also because this is the place where the first method for the orbit determination of visual binaries had been worked out by Félix Savary[1] in 1827!

Although the data processing and outcome of Gaia was discussed during the meeting, a majority of the presentations tackled other orbit determination methods. While radial velocities techniques remain a

1. Savary F. 1827. Mémoire sur les orbites des étoiles doubles et sur la détermination des orbites que décrivent autour de leur centre de gravité deux étoiles très rapprochées l'une de l'autre, Connaissance des Temps pour 1830, p. 56 et 163

classical method for binary stars and exoplanets orbit determination, it was clearly shown during this meeting that photometry brings a promising large volume of new orbits in all fields, as it also gives access to the fundamental parameters unveiling the physical nature of the objects. Typical problems in this field are associated with detecting shallow eclipses and the statistical analysis of large samples of light-curves, including gauging the ensemble properties of the detected systems. Combining transit photometry and radial-velocities is another issue, particularly when it comes to rejecting complicated configurations of "impostors". Devising efficient methods for fitting radial-velocity and astrometric data, not forgetting that precision radial-velocity determinations alone also suffer from problems such as stellar activity. Also, the implications of large sample of accurate astrometric mass determinations — together with the information brought by the orbital parameters — for exoplanets or binary asteroids for the purpose of improving the understanding of the formation models, have been discussed in detail. Numerous other astrophysical exploitations have been discussed such as the influence of third bodies (or more), tests of general relativity with pulsars, long term stability, derivation of the components spin, physical, and atmospheric parameters, etc. Modern computational techniques, modern and future observational means, as well as databases have also been presented and discussed.

The choice of speakers has reflected the various and possibly cross-domains techniques and astrophysical applications. They have been chosen such as to represent the best competence in their field, inside and outside the Gaia community. It was also the opportunity to present a review of the current developments and state of the art in the various topics (multiple stars, extrasolar planets, and Solar System). We would like to thank all the speakers for their presentation — and we forgive all those who could not succeed sending their written contribution in due time! We also thank all the participants for their interest and the many discussions during the talks and even more at the breaks.

This workshop occurred in a timely manner as it will allow developing the needed methods in advance to the Gaia data release and it provided a "first contact" between the concerned communities. In a second step, it is our hope that further conferences take place after this "Pas de Deux", such as a "Ménage à trois" as suggested by some of us, devoted to the issue of stability in multiple systems.

Frédéric Arenou and Daniel Hestroffer
Editors