CORA: A Community Platform for Stellar Occultations and Small Solar System Bodies Research

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Abstract

The observation of stellar occultations by solar system objects (SSOs) such as asteroids, Centaurs and TNOs is a powerful method to study these objects with relatively simple instrumental means, often deployed by amateur astronomers and/or by pro-am collaborations. The prediction and dissemination of occultation events, the collection of observations, and the archiving and accessibility of these data for the scientific community are essential for advancing small body research applying this technique. CORA (Collaborative Occultation Resources and Archive) is a modern web-based platform developed by us to meet these needs. Its core functions include providing predictions of occultations by small solar system bodies, archiving and presenting collected observations (reports) in a user-friendly manner, and offering rapid feedback to observers on their reports to enhance data quality and scientific usability. CORA generates occultation predictions using JPL ephemerides as well as its own independent orbital computations, ensuring a comprehensive and robust set of predictions for observers.

Introduction

The observation of stellar occultations by solar system objects (SSOs) such as planets, their moons and small bodies is a powerful technique for obtaining information about these bodies. During a stellar occultation event, the occulting object passes in front of the distant star from the observer's perspective, obscuring the star for some time, typically in the order of (tens of) seconds, depending on the size, shape and apparent motion rate of the object. By measuring the occultation light curve from one or more observers at different locations within this shadow path and combining them, fundamental physical parameter such as the size and (projected) shape of the solar system object with km accuracy, its albedo, and a highly accurate (few milliarcseconds (mas) down to sub-mas) astrometric object position within the Gaia reference frame can be derived [1]. Furthermore, the environment of the occulting object is also probed during a stellar occultation, with the potential to reveal satellites [2], rings [3] or an atmosphere down to the sub-microbar pressure level [4]. Although not the main application of stellar occultations by SSOs (except for occultations of our Moon), the target star itself may be the object to be studied [5] or the subject of a serendipitous discovery of its binary/multiple nature [6].

Objectives

The prediction and distribution of occultation events, the collection of observations, and the archiving and provision of these data and results to the scientific community are essential. CORA (Collaborative Occultation Resources and Archive) is a modern web-based platform and data service to address these needs. The main objectives of the CORA system are:

1. Compute occultation predictions of solar system objects and provide them in an easy-accessible and modern way via a web portal.
2. Collect and archive occultation observations from various sources and existing systems.
3. Analyse observed occultations and present preliminary results in an automated way.

Architecture and Ecosystem

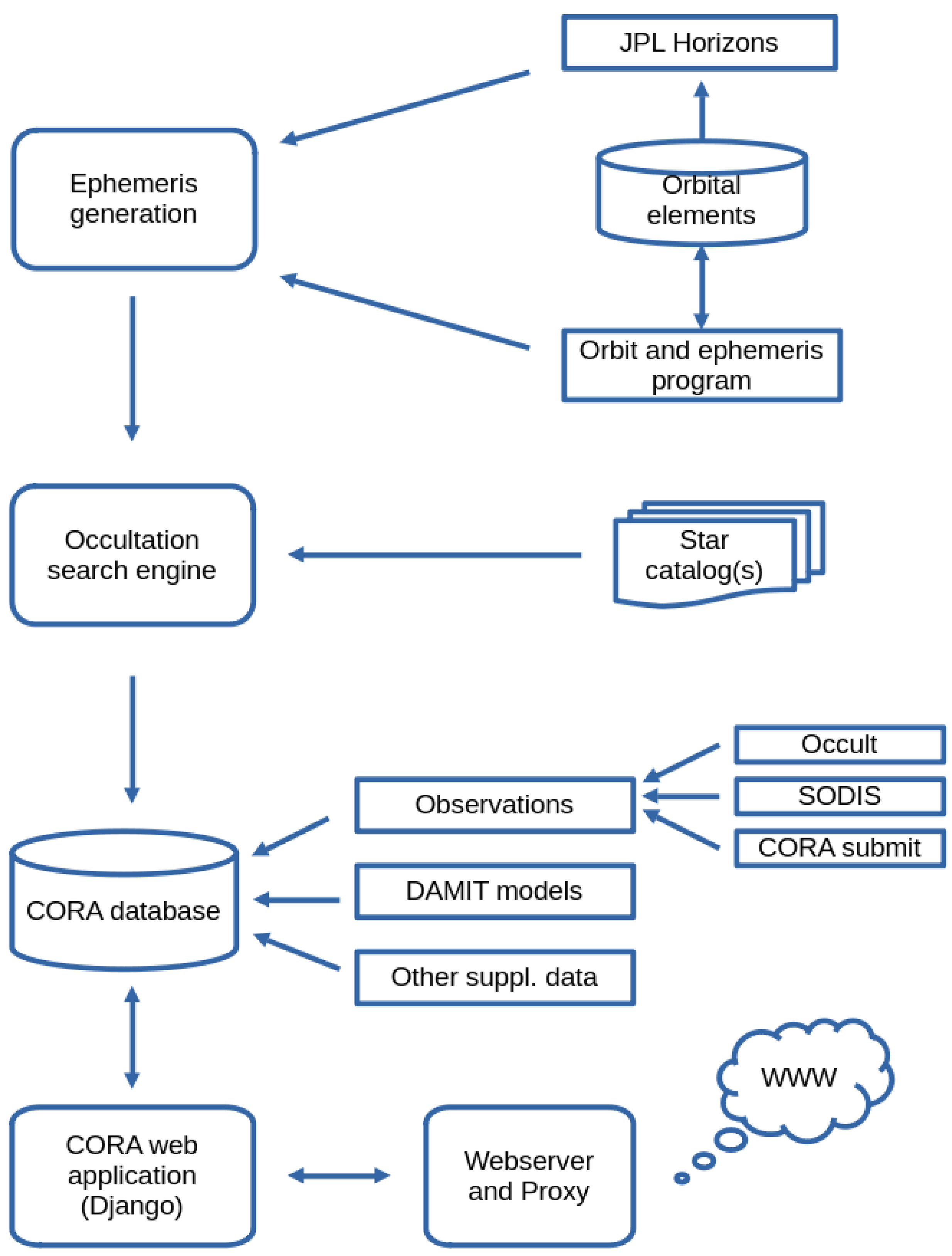

Figure 1: CORA architecture and data flow. The upper section outlines the process of building and storing occultation predictions in CORA's central database. The second fundamental task of CORA involves retrieving and processing occultation observations (reports) from diverse sources, including SODIS (Stellar Occultation Data Input System) by IOTA-ES, as illustrated in the central part of the figure. Utilizing the scientific and application processing data stored in the database, the CORA web portal system (a Django application) communicates with browser clients through a web server, as depicted in the lower part of the figure.

User Interface

Figures 2+3 provide an (incomplete) impression of the user interface and the data provided by CORA.

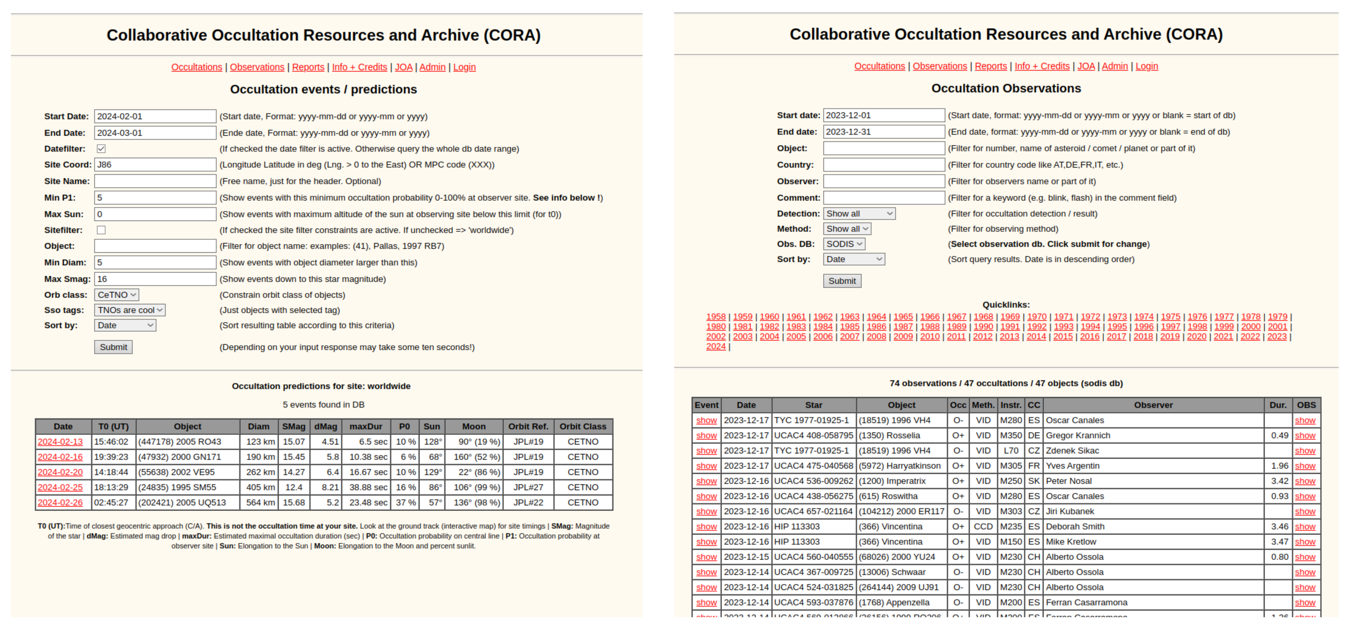

Figure 2: Starting points (index page) for the occultation predictions query (left panel) and the occultation observations archive (right panel).

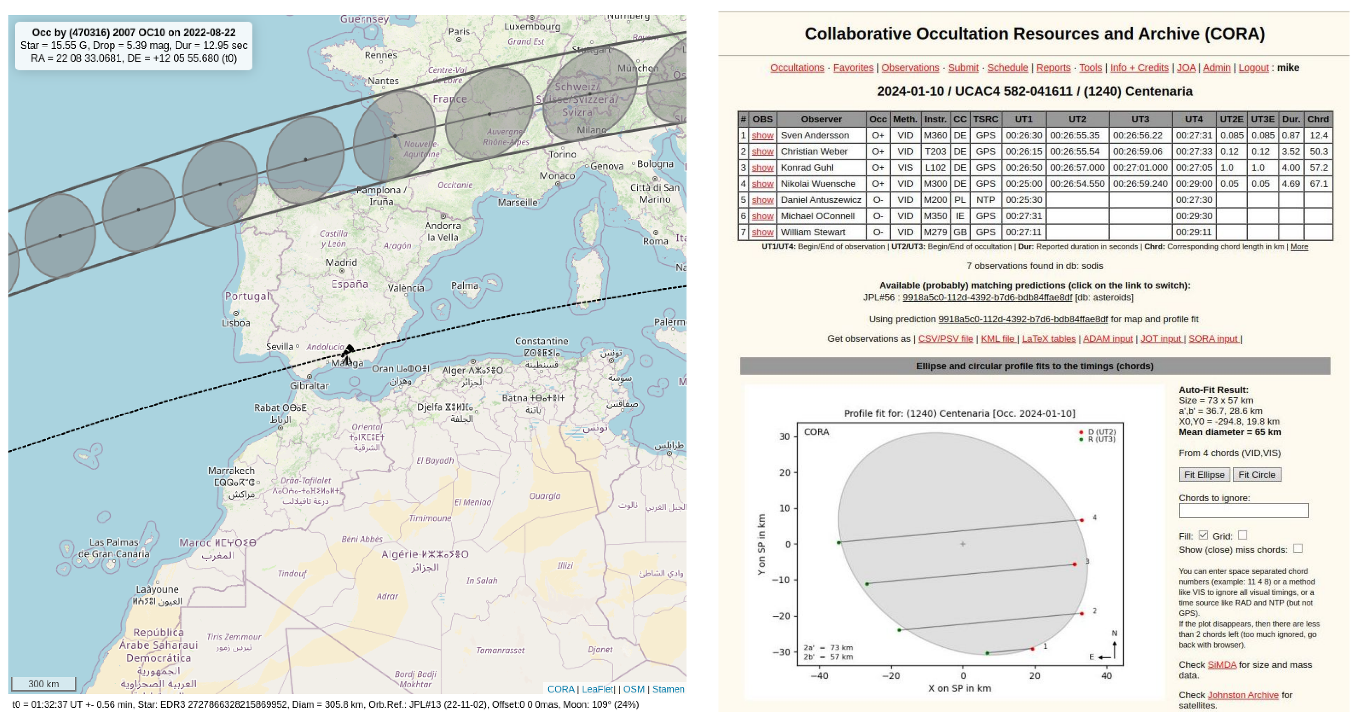

Figure 3: Example of an occultation prediction interactive map (left panel) and display of observations of an observed occultation including an automatic ellipse fit of the projected object profile (right panel).

Conclusions

- CORA provides valuable and reliable occultation predictions including some that may be missed by other tools and projects.
- CORA presents event predictions as well as reported/archived observations in a modern and user-friendly browser-based web portal and adds visualization and data analysis capabilities.
- Since CORA orbits are currently computed manually, it is planned to improve the automation of orbit calculations (rolling updates) and to increase the number of own orbit solutions for the prediction of stellar occultations.
- CORA already has some ability to schedule occultation observations by creating observation plans in the format of some well-known telescope control and camera acquisition programs with scheduler capabilities. However, this part is in an early and experimental stage and needs further development.

References

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Acknowledgements

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