Stellar Occultation by Jupiter's Irregular Moon **Kallichore**

Observer Information and Practical Guidelines

Yücel Kılıç & Juan Luis Rizos

Instituto de Astrofísica de Andalucía (IAA-CSIC), Granada, Spain

Emails: `ykilic@iaa.es`, `jlrizos@iaa.es`

On behalf of the Kallichore Worldwide Campaign Team

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Abstract

This document provides practical observing guidelines for the upcoming stellar occultation by Jupiter's irregular moon *Kallichore*. It is aimed at both professional and amateur astronomers and focuses on observational strategy, technical requirements, timing accuracy, and data submission through the Occultation Portal (https://occultationportal.org).

Contents

1 Overview of the Event

During the night of **15 December**, at around **03:09:42.220 UT** (subject to refinement), a stellar occultation by **Kallichore**, one of Jupiter's irregular satellites, is predicted to occur. The shadow path is expected to cross multiple countries (a transcontinental event).

Key aspects of the event:

- Occulting body: Jupiter irregular satellite **Kallichore** (∼2 km in diameter).
- Occulted star: magnitude $G^* \simeq$ **12.8**.
- Maximum occultation duration: ∼**0.2 s**.
- High time resolution is essential: frame times of ≤ 0.1 **s** are strongly recommended.
- Recent high-precision astrometry from the **Hubble Space Telescope (HST)** has reduced the current path uncertainty to ∼50 km (1σ width), and further refinements are expected.

A refined, fully zoomable prediction map will be continuously updated on the **Occultation Portal** (see Section 14), where observers can also access an interactive version of the map through the following links: create_report page and event chords page.

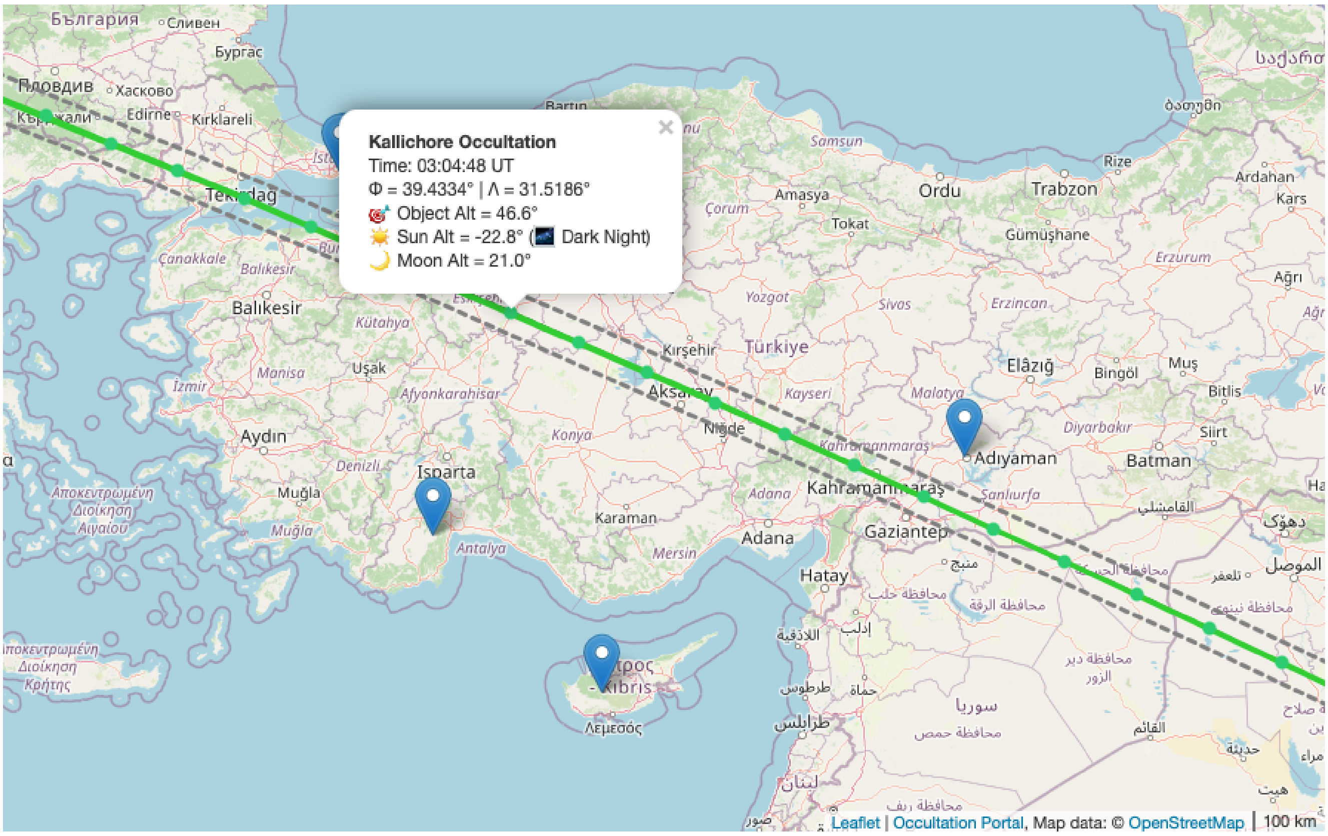

Figure 1: Interactive prediction map available on the Occultation Portal (https://opop.obspm.fr/chords/2644). The **central black line** represents the nominal shadow path derived from the latest astrometry. The **green solid lines** show the upper and lower limits of the object's projected radius. The **grey dashed lines** represent the current 1σ cross-track uncertainty. Blue markers indicate observer locations. Pop-up panels provide local circumstances such as Sun altitude, Moon altitude, and object elevation at the predicted time.

2 Scientific Motivation

Kallichore is a small (∼2 km) irregular satellite of Jupiter and a potential candidate for a future **JUICE mission flyby**. Improving its orbit is crucial to determine whether a safe and scientifically valuable close encounter is feasible.

The primary scientific goals of this campaign are:

- To obtain **high-precision timing chords** from multiple observing sites along the path.
- To significantly **improve the orbit** of Kallichore using these new constraints.
- To assess the **feasibility of a JUICE flyby** of such a small body, likely a captured trans-Neptunian object.

Every reliable detection or non-detection contributes to tightening the orbital solution, and hence directly impacts the mission design space for JUICE.

3 Event Details

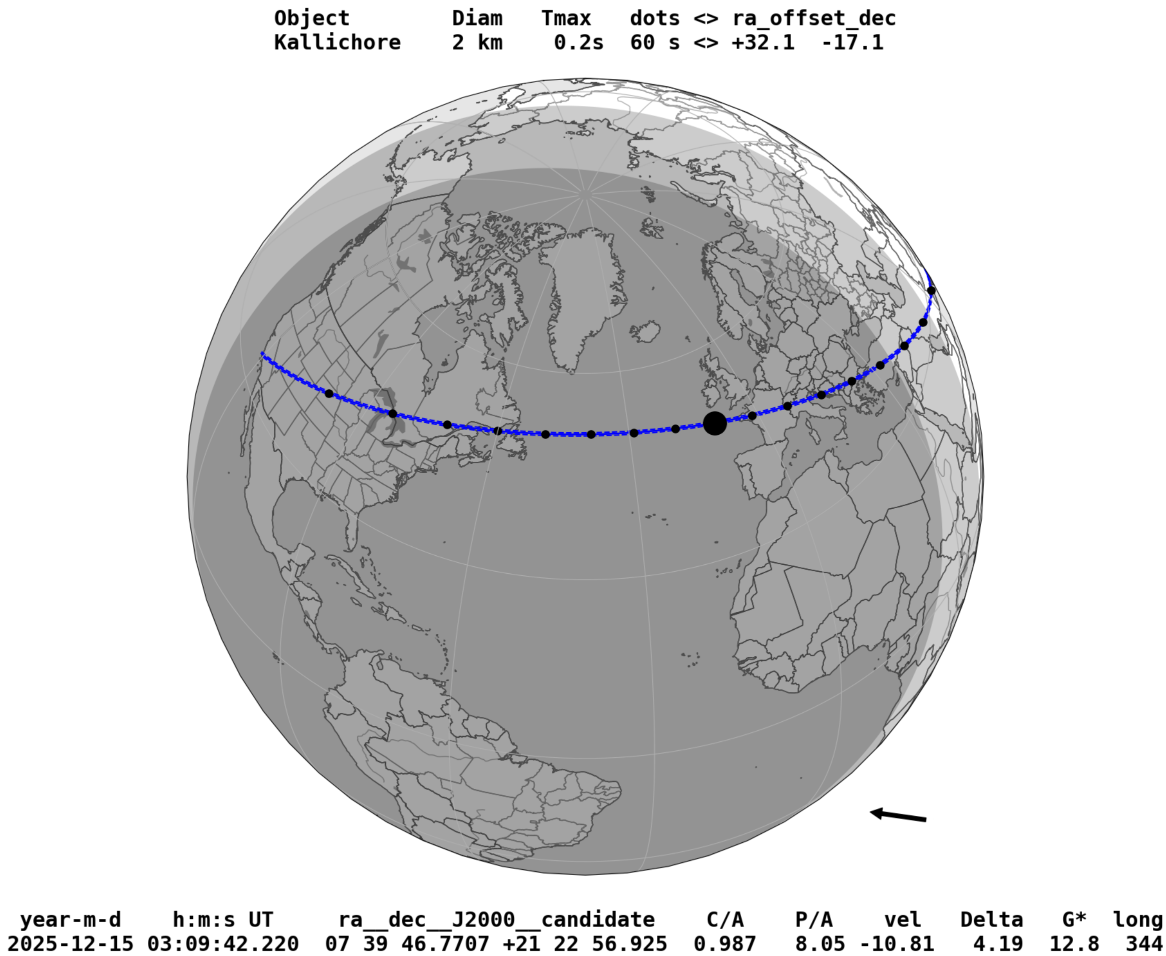

Figure 2: Latest refined prediction for the stellar occultation by Kallichore (based on HST astrometry). The blue line shows the nominal shadow path, and the dot markers indicate 60-second intervals along the track. The black symbol marks the closest approach point for the reference geodetic longitude.

Quantity	Value / Comment
Nominal central time (UT)	03:09:42.220 UT (15 December, subject to refinement)
Occulting body	Jupiter irregular satellite **Kallichore** (∼2 km)
Occulted star	Magnitude $G^* \simeq$ **12.8**
Maximum duration	∼0.2 s
Required time resolution	≤0.1 s per frame (preferably better)
Recommended SNR per frame	SNR ≥ 5
Current 1σ path uncertainty	∼50 km (HST-based solution; will be refined)
Predictions and maps	Updated on the Occultation Portal
Occultation Portal event URL	https://occultationportal.org/create_report/2644/

Table 1: Summary of the main event parameters (subject to refinement as new astrometry is obtained).

Important: All numerical values (times, path width, etc.) are subject to refinement as new observations, including additional HST astrometry, are incorporated. Observers are strongly encouraged to check the latest information on the Occultation Portal shortly before the event.

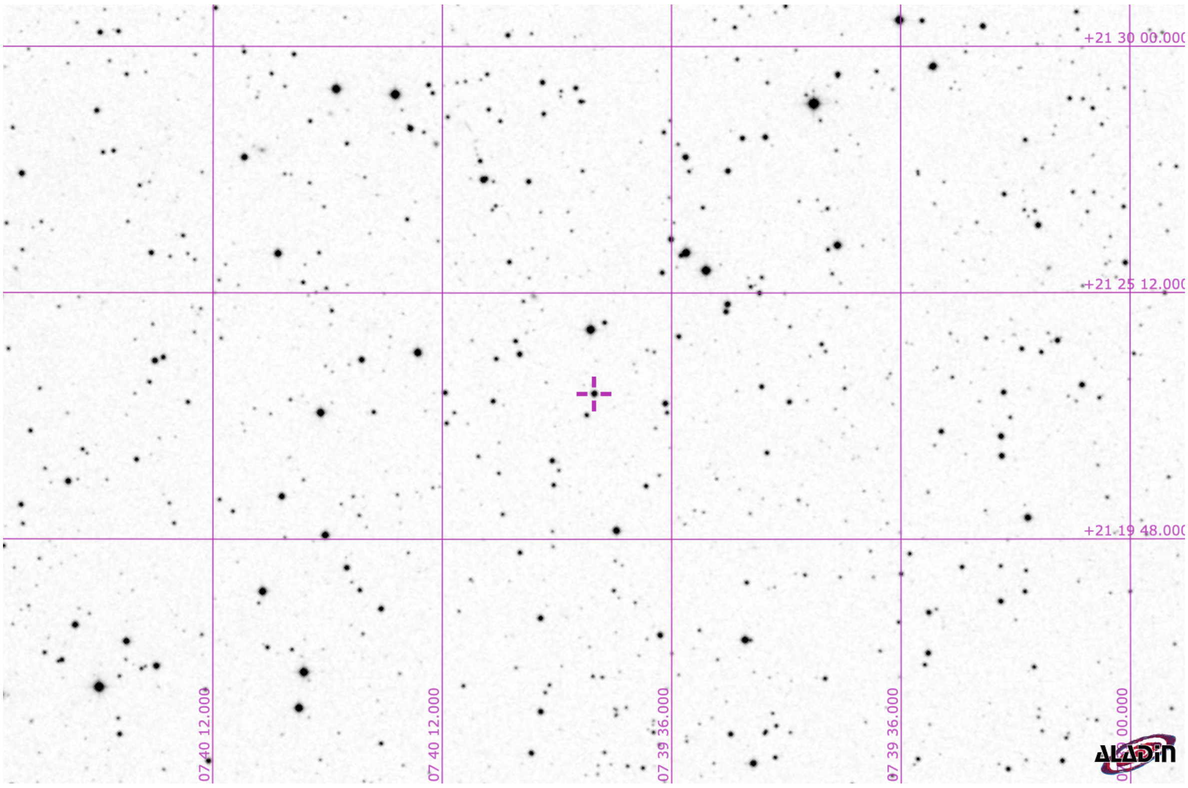

Figure 3: Sky chart showing the position of the target star at the time of the occultation, including nearby reference stars. Field of view: **24.00' × 15.81'**. An interactive version of this sky view is available at AladinLite Sky View, and on the Occultation Portal.

4 Weather Considerations

Accurate weather information is essential for planning an occultation observation, especially during winter months when cloud cover can change rapidly. We recommend checking multiple independent forecast services:

- **YR (Norway Met Office)**
  https://www.yr.no/
- **Meteoblue (Global high–resolution forecasts)**
  https://www.meteoblue.com/
- **Windy (clouds, wind, satellite imagery)**
  https://www.windy.com/
- **National Meteorological Service of your country**
  (e.g. NOAA, AEMET, Met Office, DWD, Météo-France, MGM Turkey, etc.)
- **Real–time satellite cloud maps**
  https://www.sat24.com/

For best results:

- Check forecasts **24 h**, **6 h**, and **1–2 h** before the event.
- Consider identifying a **backup site** within reasonable driving distance.
- Use satellite animations (e.g. Sat24 or Windy) to evaluate cloud motion and potential clear windows.

5 If You Are Observing with a Telescope

If you have access to a telescope and a camera, you are already in a strong position to contribute.
General guidelines:

- A telescope aperture of $\gtrsim$20–25 cm is highly desirable for a $G^* \simeq 12.8$ star at high time resolution, although smaller instruments at dark sites may still be useful. Suitable dark locations can be identified using the global light pollution atlas at https://www.lightpollutionmap.info.
- Standard sidereal tracking is sufficient; accurate guiding is helpful but not strictly required if the field stays stable.

- Keep the star image slightly defocused to spread the PSF over multiple pixels (improving photometric stability), but avoid excessive defocus that significantly lowers SNR.

The main goal is to obtain a continuous time series around the event with:

- **Time resolution** ≤ 0.1 s (preferably 0.02–0.05 s if SNR allows),
- **SNR** ≥ 5 per frame on the target star,
- At least **2 minutes** of data before and after the predicted event time.

6 If You Have a Fast Camera

Here, a "fast camera" refers to a CMOS or CCD video-type detector capable of frame rates $\gtrsim$10–20 frames/s with negligible or well-characterised dead time.

6.1 Frame Rate and Exposure Time

Aim for the highest feasible frame rate while maintaining SNR ≥ 5 per frame. As a practical rule of thumb:

- 10 fps $\Rightarrow$ frame time = 0.10 s, use an exposure time of about 0.09 s,
- 20 fps $\Rightarrow$ frame time = 0.05 s, use an exposure time of about 0.045–0.05 s,
- 50 fps $\Rightarrow$ frame time = 0.02 s, use an exposure time of about 0.018–0.02 s.

Exposure times should never exceed the frame time (1 / fps). In practice, keeping the exposure slightly below this limit leaves room for readout and helps to avoid any dead time between frames.

If SNR is too low, increase exposure time (thus lowering frame rate) until you reach SNR ≥ 5.

6.2 ROI and Binning

- Use **binning** and/or a **small region of interest (ROI)** to increase frame rate and reduce read noise.
- Include the target star and, if possible, at least one or two **comparison stars** in the same field for differential photometry.

7 If You Do Not Have a Fast Camera

If your detector has slow readout (e.g. many classical amateur CCD cameras) and cannot reach high frame rates, consider the following options.

7.1 Standard Time-Series Photometry

If you can reach exposure times of $\sim$0.5–1 s with SNR ≥ 5 on the target star:

- Your data can still be valuable to constrain non-detections, half-chords or grazing events.
- The light curve will be temporally "smeared", since the true event duration ($\sim$0.2 s) is shorter than your exposure. However, this still imposes constraints on the chord geometry and event timing.

7.2 Drift-Scan (Advanced / Optional)

Some CCD systems support a **drift-scan** mode (tracking turned off so the star trails along the detector while the shutter remains open). Time is then encoded along the trail.

- This technique is technically demanding and requires careful calibration.
- It is recommended only for observers already experienced in drift-scanning.

8 If You Do Not Have a Dedicated Astronomical Camera

A dedicated astronomical camera is strongly recommended, but if you do not have one:

- You may adapt a **planetary camera** or even a high-quality **webcam** to your telescope, provided it can reach sufficient frame rates and you can save data in minimally compressed formats.
- Laptop + inexpensive USB CMOS planetary cameras can often achieve $\geq$20 fps on a $\sim$13 mag star with adequate aperture under dark skies.
- Whenever possible, record in **SER** or **FITS** formats rather than heavily compressed video codecs.

9 If You Have More Than One Camera

If you have multiple instruments at your disposal:

- Prefer the setup that offers the **highest frame rate with negligible dead time**, while maintaining SNR ≥ 5.
- A recommended strategy is:
  - One high-speed system optimised for **time resolution**.
  - A second system (if available) optimised for **higher SNR** (slightly longer exposures, possibly a different filter) as a backup and for cross-checks.
- Two independent systems observing from the same site are extremely valuable to identify possible instrumental artefacts.

10 Filters and Photometric Considerations

For this event, the occulted star has a magnitude of approximately $G^* \simeq 12.8$ and the expected maximum duration is only $\sim$0.2 s. Therefore, the highest priority is to maximise the **signal-to-noise ratio (SNR)** per frame.

Observers are strongly encouraged to observe *without any filter* (clear / no-filter mode).

- Using no filter significantly increases photon flux and improves SNR.
- This is essential for achieving the recommended time resolution (**$\leq$0.1 s per frame**) while keeping **SNR $\geq$ 5**.
- For CMOS video cameras, "L" (luminance) or "clear" settings are appropriate.

If, for technical reasons, you must use a filter (e.g. optical system constraints or severe light pollution), then:

- Use the **broadest and brightest** passband available (e.g. luminance or wide-open clear glass).
- Avoid narrowband filters entirely (Hα, SII, OIII), as they will reduce the SNR too much for this event.

In all cases, the guiding principle is:

Maximise photon flux $\rightarrow$ maximise SNR $\rightarrow$ maximise detection probability.

11 If You Do Not Have a Telescope

If you do not own a telescope but have:

- A **DSLR or mirrorless camera** with a lens of $\gtrsim$200–300 mm focal length, or
- A small telephoto lens (e.g. 400–600 mm) on a tracking mount,

you may still attempt high-speed imaging:

- Use video mode or rapid continuous stills, pushing ISO as high as necessary while still keeping noise manageable.
- Aim for exposures approaching the time-resolution requirement ($\leq$0.1 s), at least near the predicted event time.
- Test your setup beforehand on a star of similar brightness.

12 General Notes on Cameras and Filters

- Monochrome cameras with R/V/B filters are ideal; however, colour cameras are also acceptable and individual colour channels can be analysed separately.
- Recommended recording formats:
  - **SER** video files, or
  - **FITS** image sequences.
- If you use capture software such as **SharpCap**, select SER or FITS as the recording format and avoid strong compression.

13 Computer Time Synchronisation

Accurate timing is critical for stellar occultation studies.

13.1 Windows Systems

On Windows machines, you can use time-synchronisation tools such as:

- Dimension 4,
- Meinberg NTP.

General recommendations:

1. Install the software and choose a reliable NTP server (e.g. national metrology institute, well-known public NTP server).
2. Configure regular synchronisation (e.g. every few minutes before and during the observing session).
3. Check that the reported time offset remains well below ± 0.05 s if possible.

13.2 GNU/Linux Systems

On GNU/Linux systems:

- Use `ntpdate`, `chrony` or a similar NTP client to synchronise your system clock with a trusted server.
- Ensure that your system stays synchronised throughout the whole observing session.

13.3 GPS-Based Solutions

If you have access to a **GPS-based time inserter** or a camera with built-in GPS time stamping:

- Prefer hardware GPS timestamps whenever possible.
- Document how the timestamps are generated and how they relate to UT.

14 Data Upload and Coordination

After acquiring your data:

1. **Do not delete any raw data.** Keep all SER/FITS files and related logs.
2. Contact your local or regional coordinator if applicable.
3. Upload your data and observation details to the **Occultation Portal**:
    - Event page (registration and report submission):
      https://occultationportal.org/create_report/2644/

On the Occultation Portal you will find:

- A fully zoomable, high-resolution shadow-path map.
- Up-to-date prediction refinements, including those based on new HST astrometry.
- Tools to register your site, instrument and observation details.

It is essential that all observers register and submit their data through the Portal, so that:

- Global coverage can be coordinated efficiently.
- Your contribution can be properly acknowledged in future scientific publications.

15 General Observing Notes

- Ensure that you have sufficient disk space and memory to record several minutes of data at your chosen frame rate.
- Verify the geographical coordinates and altitude of your observing site using GPS and/or services such as Google Maps or Google Earth.
- Include comparison stars in the field if possible, to enable differential photometry.
- Record from at least **2 minutes before** until **2 minutes after** the predicted event time.
- If the sky is partly cloudy, short clear intervals can still yield useful data; do not give up prematurely.
- Whenever possible, perform test runs on previous nights on stars of similar magnitude to optimise exposure time, gain and frame rate.

16 Observing Without Any Equipment

For this event, with a $G^* \simeq 12.8$ star and a very short duration ($\sim$0.2 s), scientific contribution without recording equipment is limited.

However:

- You can still support the campaign by helping with local logistics, hosting observers, or coordinating with nearby astronomy groups.
- You may also help disseminate information about the event and the campaign to local observatories, universities and amateur associations.

17 Useful Links

- **Occultation Portal – Event and Report Page**
  https://occultationportal.org/create_report/2644/
- **Occultation Portal – Main Page**
  https://occultationportal.org/
- **Time Synchronisation Tools**
  Dimension 4 (Windows): http://www.thinkman.com/dimension4/
  Meinberg NTP: https://www.meinbergglobal.com/english/sw/ntp.htm

18 Acknowledgements and Last Update

This campaign is part of a coordinated worldwide effort to improve the orbit of Jupiter's small irregular moon **Kallichore**, with the broader objective of enabling a possible **JUICE spacecraft flyby**.

The observational campaign and the refinement of the astrometric solution are coordinated by the **Instituto de Astrofísica de Andalucía (IAA-CSIC)**, Spain, in collaboration with an international network of professional and amateur observers.

Please feel free to redistribute this document and the official campaign emails to colleagues and local astronomy communities.

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