IOTA/EA2023/24 Business Report

IOTA/EA2023/24事業報告

Fumi Yoshida, Tsutomu Hayamizu

August. 25, 2024

2023年度事業計画案

Proposed Business Plan for 2023/24

IOTA/EA will conduct these five projects.

(1) Holding annual meeting ←We are having now.

(2) Providing information, discussion, research, analysis, and data storage on occultation and eclipse phenomena

(3) Website and mailing list management

(4) Cooperation and collaboration with related organizations

(5) Other activities necessary to achieve the purpose

IOTA/EAでは上記の５つの事業を行います。

(1) 年会の開催
(2) 掩蔽と食の現象に関する情報提供、議論、研究、解析およびデータの保存
(3) 会のウェブサイトおよびメーリングリストの管理
(4) 関連団体との協力
(5) その他目的達成に必要な事業

At the establishment meeting of IOTA/EA on August 27, 2023, these five issues were listed as the business plan for FY2023/24.

2023年８月27日のIOTA/EAの設立総会で、2023/24年度の事業計画としてこの５つの項目を挙げました。

I will report on our progress in these issues in fiscal year 2023/24.

これらの項目についての進捗状況をこれから報告します。

(2) Providing information, discussion, research, analysis, and data storage on occultation and eclipse phenomena
(3) Website and mailing list management

For these issues, we have accomplished the following three things.

設立総会の時にお約束したこの項目について、次の3つの事柄を達成しました。

A) Create mailing list (ml@iota-ea.org)

This is to encourage information sharing and discussion.

Mailing listの作成。情報共有や議論が可能になった（極力英語で発信している）

B) Purchase a cloud service and prepared data storage.

This is used to collect and archive observation data.

クラウドサービスでデータ保存の場所を確保。観測データの収集やアーカイブに使用

C) Create a webpage of predictions of occultation and eclipse events occurring in the East Asia region.

In order to make it easier for IOTA/EA members to find events to observe, we have created and published a prediction page limited to East Asia.

IOTA/EA会員が掩蔽イベントを見つけやすいように、東アジアに限定した予報ページを作成・公開

B) Purchase a cloud service and prepared data storage.

Noda-san will explain in detail later.

- Cloud service: pCloud

  pCloundを使って観測者からデータを収集。

  We use pCould and collect data from observers.

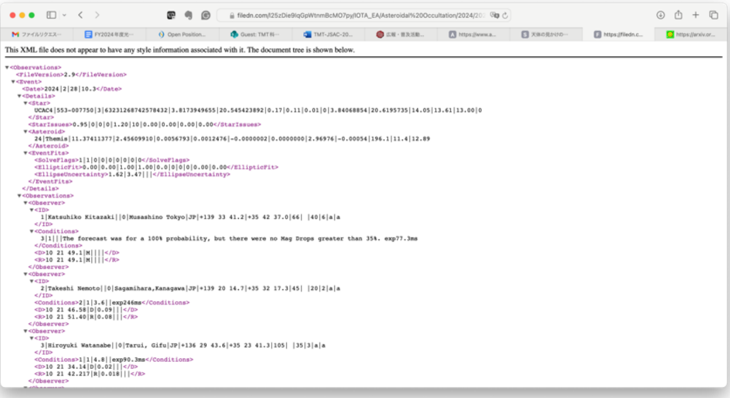
- Data archives:

  The analysis results (XML file, Reduction map, lightcurve) can be found on the IOTA/EA Observations page. Some raw data is also available.

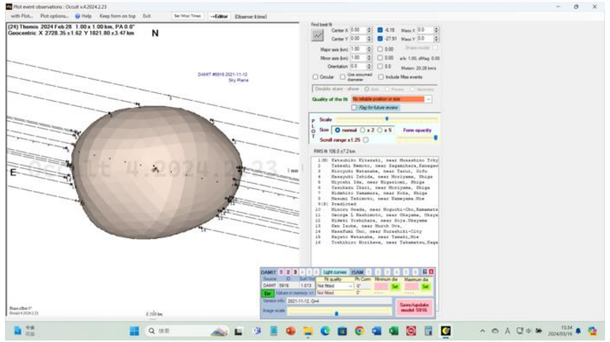
解析結果はIOTA/EAの観測結果のページから見ることができます。

Obs(*1)

XML file

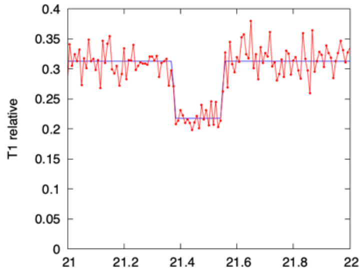


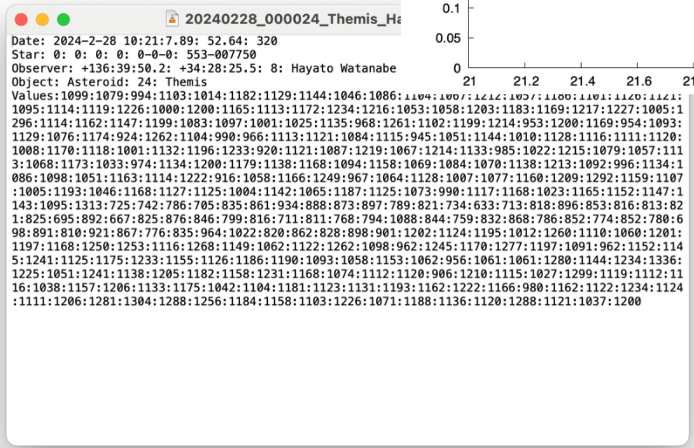
Reduction

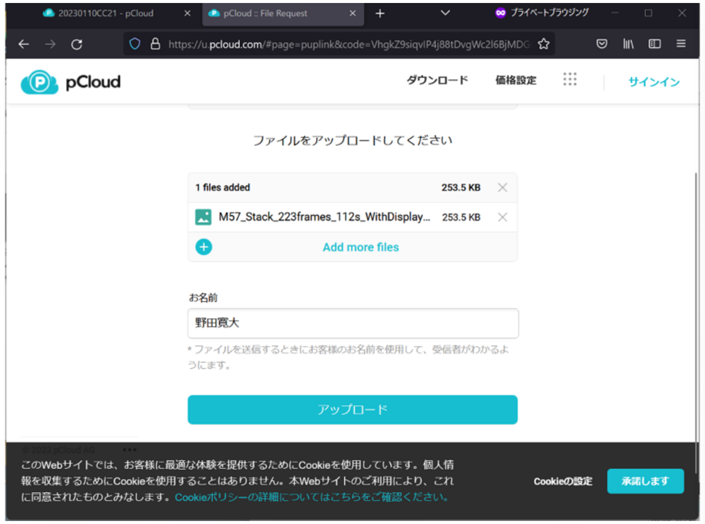


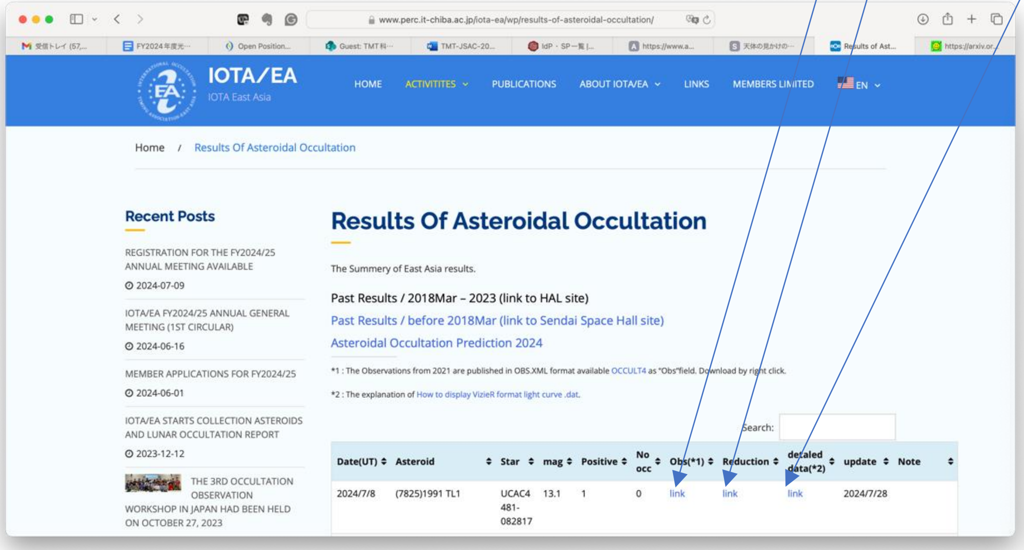
Detailed data *2

lightcurve





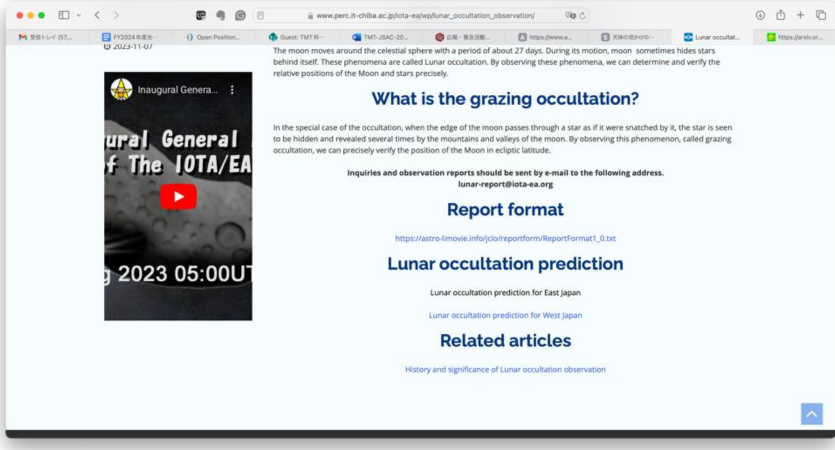




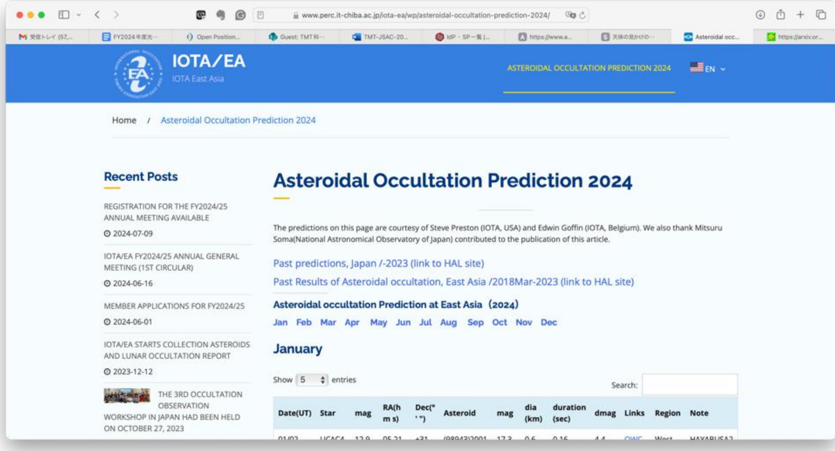
C) Create a webpage of predictions of occultation and eclipse events occurring in the East Asia region.

IOTA/EAのwebページサイトで東アジア地域で起こる掩蔽現象の予報を掲載するページを作成しました。

- **Lunar Occultation Observation**
  - https://www.perc.it-chiba.ac.jp/iota-ea/wp/lunar_occultation_observation/



- **Asteroidal Occultation Observation**
  - https://www.perc.it-chiba.ac.jp/iota-ea/wp/asteroidal-occultation-prediction-2024/



(4) Cooperation and collaboration with related organizations

IOTAメンバーと共著で発表。
IOTA/ESのメンバーからの依頼で、
IOTA/EAの活動について発表。

For this issue, we have accomplished the following things.

A) Gave a presentation as co-author in Dunham et al. who are members of IOTA

D. Dunham, J. Dunham F. Yoshida, T. Hayamizu, D. Herald, D. Farnocchia, R. Venable, J. Irwin, R. Nolthenius, N. Carlson, K. Getrost, S. Messner, R. Jones, R. Anderson, S. Preston

"NEW NEA AND OTHER ASTEROID RESULTS FROM OCCULTATIONS RECORDED BY IOTA OBSERVERS." Asteroid Comet Meteors conference, June 18-23, 2023 @Flagstaff, AZ, USA https://www.hou.usra.edu/meetings/acm2023/

NEW NEA AND OTHER ASTEROID RESULTS FROM OCCULTATIONS RECORDED BY IOTA OBSERVERS. D. Dunham[1], J. Dunham[1], F. Yoshida[2], T. Hayamizu[3], D. Herald[4], D. Farnocchia[5], R. Venable[1], J. Irwin[1], R. Nolthenius[6], N. Carlson[1], K. Getrost[1], S. Messner[1], R. Jones[1], R. Anderson[1], S. Preston[1], [1]International Occultation Timing Association (IOTA), Fountain Hills, Ariz., USA, *Email: david.dunham@kinetx.com [2]Planetary Exploration Research Center, Chiba Inst. of Tech., Japan, [3]Saga Hoshizora Astronomical Center, Japan, [4]Trans Tasman Occultation Alliance-IOTA, Wellington, New Zealand, [5]Jet Propulsion Laboratory, Calif. Inst. of Tech., Pasadena, Calif., USA, [6]Cabrillo College and IOTA, Aptos, Calif., USA.

Introduction: International Occultation Timing Association (IOTA) observers played key roles in the first occultations by NEAs in 2019 (Phaethon) and 2021 (Apophis) [1], and more recently, Didymos and Dimorphos [2,3]. Here we summarize these collaborations with SwRI, PERC, and ACROSS and present new results for Phaethon, (4337) Arecibo, and some other interesting objects.

Phaethon: We thought the first 2 years of Phaethon occultation observations nailed the orbit of this object, and in 2021, observers in Japan obtained the best observations of a Phaethon event that stands as the best by any NEA, see the sky-plane plot of Fig. 1.

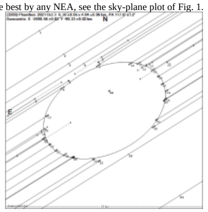


Figure 1 Timings of the occultation of 10.8-mag. TYC 2844-0734-1 by (3200) Phaethon on 2021 Oct. 3 projected on the sky plane. The point 26 above center is the predicted position of the center of Phaethon.

But a year later, the actual path of another occultation by Phaethon was observed to be over 2 km south of the prediction, almost a radius of the object. Perhaps a change in the orbit was caused by the thermal shock to Phaethon by the May 2022 perihelion passage. We will show opportunities to observe more Phaethon occultations during the second half of 2023, to quantify this possible change.

Apophis: IOTA's first observations of Apophis events demonstrated the value of setting up multiple automated stations by one or two observers, and showed the need to use only occultations of stars with good Gaia astrometric solutions for precise orbit determination. We show that same techniques and considerations have been important for Didymos events. We will describe how Fresnel diffraction effects need to be taken into account for the smallest objects, showing how previous theoretical work [4] compares with observations by small NEAs.

(4337) Arecibo: This main-belt asteroid was found to be binary during a May 2021 occultation in Australia, and confirmed with a 2nd event recorded by other IOTA observers a month later in California. The astrometric wobble of this binary object was measured by Gaia, revealing the 1.3-day period [5]. A year later, the same Australian observers found that (172376) 2002 YE25 is also likely binary, and other possible asteroidal moons from IOTA occultations will be noted [6].

Comet 29P/Schwassmann–Wachmann 1: In December 2022, IOTA observers, along with those from SwRI and Unistellar, recorded the first multi-station observation of an occultation by this enigmatic object. IOTA observers recorded one other SW1 occultation, and we will describe how others recorded the first occultation by Comet 28P/Neujmin 1.

References: [1] Dunham D. W. et al. (2021) *Planetary Defense Conf.* [2] Chesley S. et al. (2023) *ACM* submitted. [3] Souami D. et al. (2023) *ACM* submitted. [4] Altwaijry H. A. and Hyland D. (2013) Paper AAS 13-942, Astrodynamics Specialist Conf., Hilton Head, S.C. [5] Tanga P. (2022) https://www.cosmos.esa.int/documents/29201/6953755/EAS2021-S15-Tanga.pdf . [6] Herald D. et al. (2020) *MNRAS 499*, 4570-4590.

B) Gave a presentation at a conference attended many IOTA/ES members.

Fumi Yoshida

"Forming a new East Asia occultation group."

Colloquium in honor of Professor Bruno Sicard - Stellar occultations: a route to major advances in Planetary Sciences -, April 22-26, 2024 @Paris, France https://bsicardy2024.sciencesconf.org

(5) Other activities necessary to achieve the purpose

For this issue, we have accomplished the following things.

設立総会の時にお約束したこの項目について、次の4つの事柄を行いました。各項目について説明します。

A) **Call for Observing Campaigns**
B) **Hold occultation observation workshops**
C) **Distribute Observing Manual**
D) **Publications**

(5)-A) Call for Observing Campaigns

Occultation observation campaigns were conducted for these six small bodies in FY2023/24.

- 2023/08/29:17UT (704) Interamnia (PI: Watanabe, Ha.)
  Observed at 16 different sites, Positive detection: 5 sites, Lightcurves from 2 sites could not be analyzed due to very small amplitude, Failed: 9 sites.

16地点で観測。5地点でpositive、2地点での観測は減光が小さくて解析不能、9地点で観測不成立

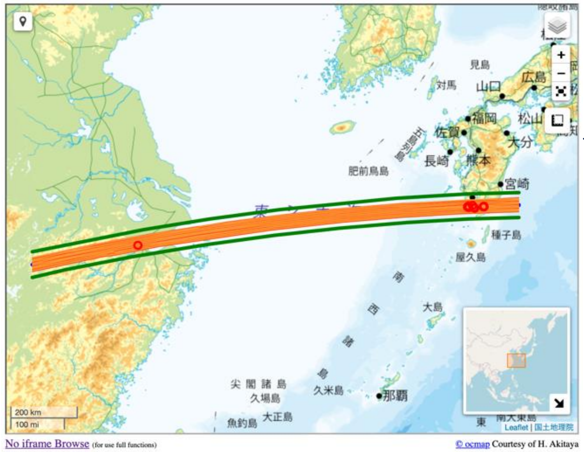
- 2023/9-10 2004 UX10, 2015 MQ204, 2002 XW93, 1995 SM55 (PI: Arimatsu, K.)
  Results are under analysis. 結果は解析中

- 2023/10/27:13UT (155140) 2005 UD (PI: Yoshida, F.)
  Observed at 14 different sites, Negative detection: 11 sites, Cloud/Failed: 3 sites

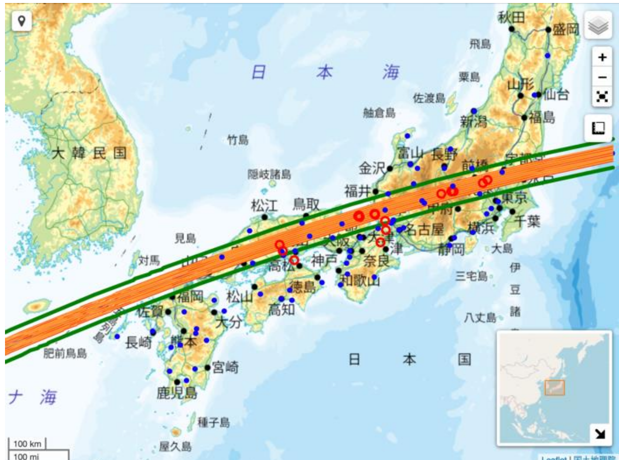
14地点で観測。11地点で減光なし。2地点が曇り。1地点で機材のトラブル等で不成立

- 2023/11/25:13UT (155140) 2005 UD
  Observed at 16 different sites, Negative detection : 11 sites, Failed : 5 sites

16地点で観測。11地点で減光なし。5地点で機材のトラブル等で不成立



All negative detections



Perhaps we have lost the exact orbit of 2005UD?
The next time we observe an occultation by 2005UD, we should do so after careful astrometry.

2005UDの正確な軌道を見失った？
次回2005UDによる掩蔽を観測する時は位置観測を入念にしてからtry。

(5)-B) Hold occultation observation workshops

2023年10月27日鹿児島市立科学館にて実施
現地参加者34名(大学生21名)
オンライン参加者12名
ワークショップで小惑星2005UDによる掩蔽の観測方法や、掩蔽観測に利用できる観測装置やアプリ、解析プログラム等を学んだ。

- Organized by IOTA/EA https://fumi-yoshida.wixsite.com/occultation-ws

  Conducted at Kagoshima City Science Museum on October 27, 2023

  On-site participants: 34 (21 university students)

  Online participants: 12

  Participants learned how to observe the occultation of asteroid 2005UD and how to use instruments, applications, and analysis programs for occultation observations.

Program

10:00-10:10　WSの準備、受付
10:10-10:20　挨拶と連絡事項
10:20-10:40　2005UDの掩蔽観測の意義（吉田二美（産業医科大学・千葉工業大学））
10:40-11:00　2005UDの掩蔽全般と報告方法、布陣 （早水勉（佐賀市星空学習館））
11:00-11:30　2005UDの掩蔽観測方法 （山村秀人 （特定非営利活動法人花山星空ネットワーク））
11:30-12:00　観測計画／ベテルギウス食，Phaethon について（早水勉（佐賀市星空学習館））

12:00-13:30　昼食・休憩
昼食は館内に喫茶はあります。（ルーカ）
https://www.facebook.com/profile.php?id=100069119055520
他には近くにガスト、イオン鴨池店、県庁しょくあります。

13:30-14:00　超高速カメラでミリ秒以下の現象を捕える（中森健之（山形大学））
14:00-14:15　掩蔽観測支援地図アプリocmap　（秋田谷洋（千葉工大））
14:15-14:45　高精度時刻同期について　"HACSTIP Ver.2 + ちょうちんコバンザメ"　（宮下和久（JOIN））
14:45-15:00　Limovieの新機能　（宮下和久（JOIN））
15:00-15:30 観測で注意したいこと（渡部勇人（JOIN））

15:30-15:40 休憩

15:40-16:10 IOTA/EA発足・始動・観測キャンペーン（早水/吉田）
16:10-16:40 ジュニア層への観測普及について（加瀬部久司（JOIN））

16:40-16:50 まとめ
16:50-17:00　WSの片付け
17:00　観測布陣地へ出発

協力: 鹿児島市立科学館
https://www.k-kagaku.jp

Yamamura-san will give an presentation later.

- Five workshops on IOTA/EA cooperation were held.

(5)-C) Distribute Observing Manual

English version

https://drive.google.com/file/d/1nA3Dqac3Syzp9lr36ly5pWM1vahl1zur/view?usp=share_link

Japanese version

https://drive.google.com/file/d/1Jby33vY_8QOkKQ9sOiGwbfBbJCXrpWCi/view?usp=share_link

このリンクからダウンロードできます。

Observation manual for stellar occultation by asteroids

Edited by IOTA/EA

February 2024

2. is related to the observation camera commonly used in Japan. Most of the occultation observers in Japan use QHY174M-GPS (from QHY) or ASI290MM (from ZWO). QHY174M-GPS, which was developed for occultation observations, became popular as a standard camera for occultation observations around 2017 after the observation of stellar occultation by the Kuiper Belt object (486958) Arrokoth, which is the flyby target of NASA's New Horizons spacecraft. On the other hand, since the QHY174M-GPS is quite expensive, it was not widely used by Japanese amateurs. Instead, the ASI290MM, which was developed as a popular planetary imaging camera, became popular among Japanese amateurs. However, the ASI290MM camera does not have a built-in GPS function. This camera does not have a built-in GPS function, so it requires a unique observation method (see Chapter 4).

(a) QHY174M-GPS (b) ASI290MM

図 4: (a) QHY174M-GPS (made by QHY) is a mainstream camera among overseas occultation observers. (b) ASI290MM (made by ZWO) is popular among Japanese occultation observers because of its low price. But this ASI290MM has no GPS function. To compensate for the lack of GPS function, it is necessary to use a GPS module at the same time (see text for details).

The aforementioned occultation observations of (486958) Arrokoth were supported by the New Horizons mission and were a great success. The occultation observations predicted that (486958) Arrokoth is a contact binary before the spacecraft flyby. In Japan, occultation observations of the Apollo-type asteroid (3200) Phaethon, the flyby target of the DESTINY+ mission, were systematically performed in 2019, 2021, and 2022. The 2021 observations were performed from 35 different sites, and then the positive detections were reported from 18 sites. These observations helped to determine the exact size and shape of Phaethon. The observation of the occultation by Phaethon was also a great success in 2022 (see chapter ?? for details). The size and shape of asteroids obtained from occultation observations leave little room for error. As these examples show, occultation observations have recently attracted the attention of professional researchers as a tool for solar system exploration missions.

8

of the time between the start of exposure of the nth frame and the frame output. Based on this principle, Limovie creates a model of the phenomenon, including light diffraction, and compares it with the photometric results of the observation, then obtains the most accurate time of the phenomenon. The light curves obtained from the observation and the time of the phenomenon calculated from the model fit are shown in Figure 8.

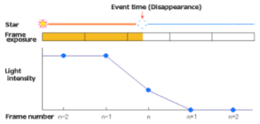


図 7: When occultation (dimming) occurs in the middle of the exposure of the frame.

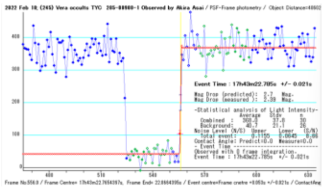


図 8: We analyzed the video shown in Figure 6, and then fit the diffraction simulation model to the light curve of the star occulted by the asteroid to obtain the most likely value of the event time. As a result, we found that 17h43m 22.785 ± 0.021s was the most likely value of the event time. This means that the event occurred 0.081s before the timestamp of 17h43m 22.866s, which is the timestamp of the frame in which the faint star image was seen.

2.3.3 推定時刻誤差

まず，前項のような求め方をする上で誤差要因となるのは，ライトカーブ上に載っているノイズである．これらは，撮像素子上の読み取りノイズや，大気の揺らぎによる「星の

13

小惑星による掩蔽観測マニュアル

早水，宮下，渡辺，山村，吉田

IOTA-EA 掩蔽観測チーム編

February 2024

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2.3.2 測光結果から現象時刻の最確値を求める

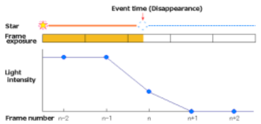

図 7: フレーム露光期間の途中で掩蔽（減光）が起きた場合.

図 8: 回折シミュレーションモデルにフィットさせて現象時刻最確値を求める図 3 のビデオの解析を行い，現象時刻として 17h43m22.785 +/- 0.021s が得られた．淡い星像が見られたフレームのタイムスタンプの 17h43m 22.866s よりも 0.081s 前に現象が起きたことになる．

ビデオのコマ送り（フレーム画像の目視）では，フレームの出力間隔が時間分解能であった．ビデオに映る星像を，静止画カメラと同じように光度測定することができれば，光量変化曲線（light curve）が得られ，それを用いて，更に時刻精度を向上させることができる．この測定は，Limovie や PyMovie をはじめとするビデオファイル用の光量変化測定ソフトウエアを用いることで可能となる．

図 7 は，第 n フレームの露光期間の約 3 分の 1 の時点で減光が起きた場合を示している．掩蔽現象により星像が瞬時に消えたと仮定すると，第 n フレームにはそれ以前の 3 分の 1 の明るさの星像が写っていることになる．逆に，星像が潜入前の 3 分の 1 の明るさであれば，第 n フレームの露光開始から，フレーム出力間隔の 3 分の 1 の時間後に現象が起きたことがわかる．これにより，フレーム出力間隔よりさらに精密な現象時刻を求

13

図 29: 縮小光学系構成例

図 30: レデューサー組み合わせ例．左:×0.63+×0.5 レデューサーの組合せ．右:×0.63+×0.33 レデューサーの組合せ

38

(5)-D) Publications

https://www.perc.it-chiba.ac.jp/iota-ea/wp/publications/

- **Articles**
  - Ko Arimatsu, Fumi Yoshida, Tsutomu Hayamizu, Miyoshi Ida, George L Hashimoto, Takashi Abe, Hiroshi Akitaya, Akari Aratani, Hidekazu Fukuda, Yasuhide Fujita, Takao Fujiwara, Toshihiro Horikawa, Tamio Iihoshi, Kazuyoshi Imamura, Ryo Imazawa, Hisashi Kasebe, Ryosuke Kawasaki, Hiroshi Kishimoto, Kazuhisa Mishima, Machiko Miyachi, Masanori Mizutani, Maya Nakajima, Hiroyoshi Nakatani, Kazuhiko Okamura, Misaki Okanobu, Masataka Okuda, Yuji Suzuki, Naoto Tatsumi, Masafumi Uno, Hidehito Yamamura, Mikoto Yasue, Hideki Yoshihara, Masatoshi Hirabayashi, Makoto Yoshikawa, Diffraction modelling of a 2023 March 5 stellar occultation by subkilometer-sized asteroid (98943) 2001 CC21. Publications of the Astronomical Society of Japan, 2024, https://doi.org/10.1093/pasj/psae060
  - Ye Yuan, Chen Zhang, Fan Li, Jian Chen, Yanning Fu, Chunhai Bai, Xing Gao, Yong Wang, Tuhong Zhong, Yixing Gao, Liang Wang, Donghua Chen, Yixing Zhang, Yang Zhang, Jun Cao, Xinru Han, Xiang Zeng, Peiyu Ye, Jianguo He, Guihua Niu, Xiansheng Zheng, Yuchen Lin, Tong Liu, Yuqiang Chen, Zhendong Gao, Weitang Liang, Chengcheng Zhu, Zhiqiang Hu, Wei Zhang, Yue Chen, Zhuo Cheng, Yang Zhang, Tianrui Sun, Chenyang Guo, Yue Lu, Jiajun Lin, Wei Tan, Jia Zhou, Jun Xu, Jun He, Jiahui Ye, Delai Li, Shuai Zhang, and Qingyue Qu, New constraints on Triton's atmosphere from the 6 October 2022 stellar occultation. A&A, 684, L13 (2024) https://doi.org/10.1051/0004-6361/202348460
  - Fumi Yoshida and Tsutomu Hayamizu, "Forming a New East Asia Occultation Group (IOTA/EA)", The Astronomical Herald (Astronomical Society of Japan), 2024, 117 (7), pp. 449-457.
  - Fumi Yoshida, "Forming a New Occultation Observation Group in East Asia", Journal for Occultation Astronomy, 2023, Vol. 13, No. 4. p.27: [pdf]
  - Hayato Watanabe, "〈2022 年度日本天文学会天文功労賞〉 小惑星ディディモスによる恒星食観測への挑戦", 天文月報(公益社団法人 日本天文学会), 2023, Vol. 11, p.578 (Japanese article):
  - Tsutomu Hayamizu & Fumi Yoshida, "東アジア連携推進 掩蔽観測の国際組織「IOTA/EA」設立", 星ナビ(AstroArts), 2023年8月号, p.76 (Japanese article)
- **Presentations**
  - Fumi Yoshida, "Forming a new East Asia occultation group", 2023 IOTA Meeting on July 15-16, 2023
  - D. Dunham, J. Dunham F. Yoshida, T. Hayamizu, D. Herald, et al. "NEW NEA AND OTHER ASTEROID RESULTS FROM OCCULTATIONS RECORDED BY IOTA OBSERVERS", Asteroid Comet Meteors, June 18-23, 2023 @Flagstaff, AZ, USA
  - Fumi Yoshida, Tsutomu Hayamizu, Hayato Watanabe, Mitsuru Soma, Kazuhisa Miyashita, Hiroshi Akitaya, Hirotomo Noda, Toshihiro Horaguchi, "International Occultation Timing Association, East Asia (IOTA/EA) will be established in this summer." 2023 Asia-Pacific Regional IAU Meeting, August 7-11, 2023, @Fukushima, Japan
  - Fumi Yoshida, "Forming a new East Asia occultation group", Colloquium in honour of Professor Bruno Sicard - Stellar occultations: a route to major advances in Planetary Sciences -, April 22-26, 2024 @Paris, France
- **News Coverage**
  - "小惑星観測 アマの力 アジア研究者ら 観測団体", October 18, 2023, 読売新聞夕刊 (東京版) (Japanese article)