Optical Follow-up of Nova AT 2020aapw with the Cristina Torres Memorial Observatory

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Nova AT 2020aapw

Nova AT 2020aapw is a Fe-II type extragalactic nova in the Andromeda galaxy. This transient phenomenon occurs when a white dwarf is in a binary system with a larger companion that is close enough for matter to extend over its Roche Lobe. Matter transfers to the white dwarf forming an accretion disk and is heated until the hydrogen in this dense atmosphere begins fusing rapidly into helium, becoming as bright as ~ 1 to 10^5 solar luminosities, before decaying in brightness within less than a day to months.

AT 2020aapw was discovered on 2020-11-20 09:36:00 UT by the All Sky Automated Survey for SuperNovae (ASAS-SN) collaboration. ASAS-SN issued a transient discovery alert which was responded by various teams around the world tasked with follow-up photometric and astrometric analysis, as well as spectral classification, of the event. The Time Domain Astronomy Group (TDAG) at UTRGV performed observations in response of the alert over the course of 4 days with the purpose of confirming the event and measuring the decaying brightness of the target.

Photo credits Americo Hinojosa, Victor de los Santos

Fig. 1. CTMO's main dome accompanied by 9 mini-domes. The facility collaborates with astronomy laboratory course instructors to provide hands on experience to students as part of course assignments.

Cristina Torres Memorial Observatory

TDAG consists of undergraduate and graduate students and volunteers of various academic backgrounds who operate the Cristina Torres Memorial Observatory (CTMO), located within Resaca de la Palma State Park grounds in Olmito, Tx, as part of UTRGV's Center for Gravitational Wave Astronomy (CGWA).

The observatory houses a PlaneWave 17 in. telescope and FLI 4k CCD imager with multiple SDSS and Johnson filters. The observatory's main astronomical research focus includes transient event detection and gravitational wave optical counterpart follow-ups, as well as asteroid, active galactic nuclei, and variable star time-domain observation and analysis. CTMO is involved in public outreach activities with the South Texas Astronomical Society (STARS), and it also serves as testbed in developing technology for the Transient Optical Robotic Observatory of the South (TOROS) collaboration.

Initial Detection and Alert

2020-11-20 09:36:00 UT, 16.6 ABMag

The discovery was made using the Cassius 14 cm telescope atop Cerro Tololo, Chile, with an absolute magnitude of 16.6 in the SDSS g' filter. The discovery report (No. 90361) was sent to the Transient Name Server (TNS) 4.5 hrs. later by the ASAS-SN team, and it was relayed to the TDAG by Lucas Macri (Texas A&M). Alert took place around dawn in Brownsville, and observation was planned for day 2.

Follow-up

2020-11-21 06:30:09 UT, 17.68 ABMag

The Zwicky Transient Facility measured an absolute magnitude of 17.68 with the Samuel Oschin 48 in telescope. Day 2 observations from CTMO could not be performed due to cloudy skies. However, weather conditions improved the following 4 nights.

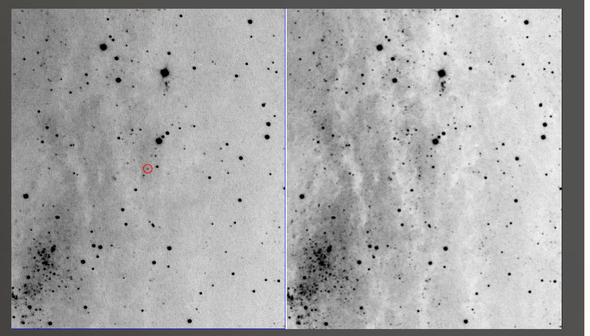

Fig. 2. Transient in CTMO image 2020-11-22 (left) and same region of Andromeda galaxy from Pan-STARRS DR2 catalog (right).

2020-11-22 04:36:28 UT, 18.45 ABMag
2020-11-23 02:31:46 UT, 18.86 ABMag
2020-11-24 02:09:55 UT, 19.33 ABMag
2020-11-25 02:10:23 UT, 19.77 ABMag

All frames were taken in the SDSS g' filter using 60 s exposures. Session of Nov 22 consisted of 15 frames, while the rest were 60 frames each. Multiple frames are stacked in order to increase the signal to noise ratio and decrease the error in the fainter signals.

Analysis

Claudio Balcon reported on 2020-11-20 21:28:15 in TNS that he found the nova spectrum to be similar to a Fe-II type.

TDAG shared dark and flat calibration frames with L. Macri, in charge of producing a light curve of the nova brightness decay. L. Macri performed time-series point spread function photometric analysis using DAOPHOT/ALLFRAME (Stetson 1987, 1994) for each day. The calculated seeing for the four observations ranged from 2.5 and 3.2".

More than 850 stars correlated with the Pan-STARRS DR2 photometric catalog were used to calibrate the measurements (Magnier et al. 2020). Delta mag. plots in Fig. 3 show the decrease in brightness in comparison to other point sources in the field by magnitude. Fig. 4 shows the decay in magnitude over all 6 observations. Decay rate from CTMO follow-ups is 0.46±0.05 mag/day.

Photometric findings were published in the Astronomer's Telegraph No. 14228. Images are currently used by TDAG to test analysis functions.

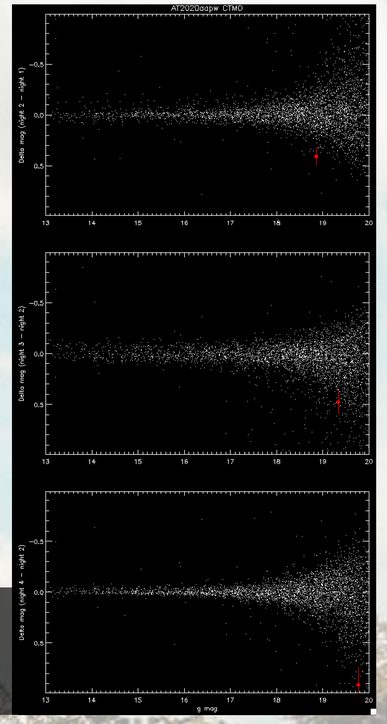

Fig. 3. Delta magnitude plots for nights 2-1, 3-2, 4-2. The target decreases by ~0.41, ~0.47, and ~0.91 respectively.

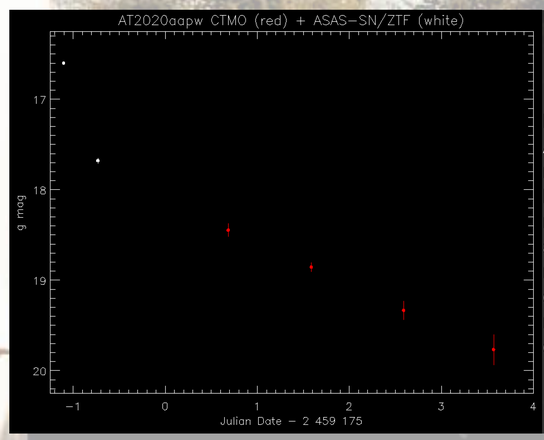

Fig. 4. 5 day light curve of AT 2020aapw absolute magnitude in SDSS g'. Magnitude decays much rapidly in the first 4 hours after detection than the next 4 days, where Rate of decay is 0.46±0.05 mag/day from CTMO observations.

Developments

The process of receiving alerts and conducting follow-up observations is currently performed entirely manually, although our goal is to fully automate the instrumentation and data analysis at CTMO. We built a data reduction pipeline over the Summer 2021 using Python for the first automatic data analysis step with the goal of standardizing the image clean up process across TOROS sites. The program automatically bias, dark, and flat corrects and plate solves a set of images through a modular set of tools. This library of functions is planned to be expanded and configured into further analysis workflows such as catalog cross-match calibration, light curve generation and transient detection.