

ROMANIA OBSERVED FROM ROMANIA: AN EDUCATIONAL PROGRAM FOR OBSERVING ASTEROID (7698) ROMANIA DURING ITS OPPOSITION IN 2015

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Abstract. The project *Romania observed from Romania* was started for observing the asteroid (7986) Romania during its opposition in April-May 2015. These coordinated observations were devoted mainly for astrometry using telescopes over the Romanian territory. The main objective of these observations was to initiate students and amateurs to the astronomical observations of Solar System objects.

Key words: Asteroids – Observations – Astrometry – Survey.

1. INTRODUCTION

International Astronomical Union gave the name Romania to the asteroid with the catalog number 7968. The definition with which this asteroid was named is the following: Romania is a country located in southeast Europe intersected by the 45 degree parallel of latitude. The capital is Bucharest. Its surface area is about 1/3 of France and its geography contains the Carpathian mountains, the Danube river, and the Black Sea. Its cultural history spans two millennia and the Romanian language is of Latin origin (Spahr and Williams, 2012).

The provisional name of the asteroid was 1981 EG15 and the asteroid was dis-

covered on 1 March, 1981 by the astronomer S.J. Bus in Siding Spring Observatory, in a study of asteroids called the U.K. Schmidt-Caltech Asteroid Survey.

The asteroid Romania revolves around the Sun in 1,122.29 days. The asteroid is located in the inner part of Main Belt of Asteroids. Its osculating elements are: $a = 2.1135108$ A.U., $e = 0.1269650$, $i = 1.99603^\circ$ where a is the semi-major axis, e is the eccentricity, and i is the inclination of its orbit. Its closest distance to Earth is of 0.83 A.U. (approximately 124,166,340 km). The asteroid has an elliptical orbit that is stable and well determined and it does not pose any threat to Earth.

Except its osculating elements no other parameters were known concerning the asteroid (7968) Romania. Its absolute magnitude was estimated to 15.6; using this absolute magnitude, in the assumption of an albedo of 0.15, the computed diameter is about 2.7 kilometers. While this assumed albedo has no observational estimate, the diameter of (7968) Romania could span the range of 2–3 km.

In May 2015 this asteroid reached a distance of 0.91 astronomical units (approximately 136 million of kilometers) from Earth during its opposition (Figure 4). The asteroid reached an apparent magnitude of 16.9, thus being accessible for observations and astrometric measurements even for a 20 cm telescope. The Sun-Earth-asteroid geometric configuration is favorable for observations. Indeed the next such a low apparent magnitude will occur only in 2025.

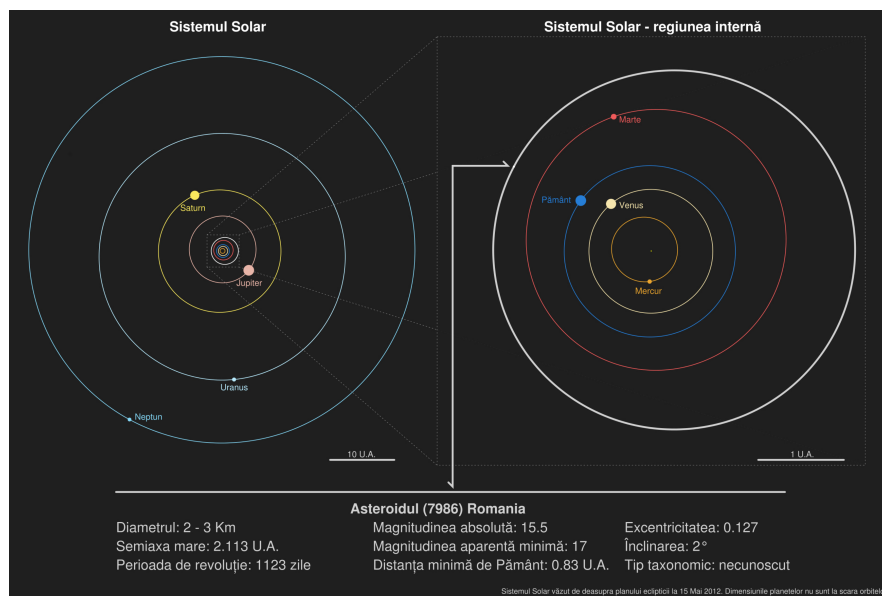


Fig. 1 – Solar System as seen in May 2015 (left side). The zoom of the inner Solar System shows telluric planets on their orbits as well as the asteroid Romania and its orbit (right side).

We take profit of such favorable geometry and conceived a formal educational program called *Romania observed from Romania*.

2. PROJECT ROMANIA OBSERVED FROM ROMANIA

The main objective of this project was the implication of professors and students, as well as amateur astronomers and professionals into an intense observational program thus promoting the research of asteroids and more general the observation of solar system objects. There are many scientific fields in astronomy which could produce valuable results from a collaboration between professional and amateur astronomers (Mousis *et al.*, 2014; Birlan *et al.*, 2010).

The educational objective was splitted in several sub-objectives, namely:

- knowledge of celestial sphere (position of stars on the sky, fundamental plans, ephemerides, Solar System structure);
- scheduling and planning the observations for Solar System objects;
- training using modern telescopes and techniques (GOTO mount, CCD, robotic telescopes, image processing, etc);
- creation of competencies for observations and data reduction for solar system objects; extrapolation of such techniques to Near-Earth Objects and artificial satellites.

The obtained science was splitted in several sub-items, namely:

- calculus of dynamical parameters of (7698) Romania and the long-term evolution of this asteroid;
- the obtention of its physical parameters;
- creation of the database of observations for asteroid Romania;
- publishing the results and sharing the experience of this project.

The persons who were in charge of observations were called *trainers*. Their duty was the local organization of observations, namely the advertising, the training of local participants, and the data-processing. The places where the observations were realized over the Romanian territory were called *working points*. The Romanian authors of this article are actually the trainers of the project.

The observations were done using two techniques:

- directly, thus the groups of participants are observing inside the dome (or inside the control room) of the telescope located in Romania;
- remotely, thus the group of participants from Romania are present into a conference room on which the projection of remote telescope and the remote control room were available. Thus they could ask questions to astronomers located at thousand of kilometers abroad.

The list of telescopes and CCD detectors are listed in Table 1.

Table 1

List of trainers of the program *Romania observed from Romania*

Trainer	Location	Telescope and camera	Technique
Maximilian Teodorescu	Măgurele, Ilfov	200mm F/5 Newton,	Directly
Cristian Dănescu	Păulesti, Prahova	camera DMK21 Telescop Maksutov-Newtonian MN190 diameter 190 mm F/5.2, camera CCD Atik314L+ mono	out of the city Remotely
Lucian Hudin	Cluj-Napoca	Reflector 30cm f/5, CCD Atik 383L+ mono	Directly
Radu Gherase	Vălenii de Munte	Reflector RC 20 cm f/8, CCD Atik 314L+ mono	Remotely
Ciprian Dumitru Vîntdevară	Observatorul Astro-nomic din Bîrlad	Newton 200mm f/4 CCD ATIK 320E Filtre LRGB	Directely and remotely
Elisabeta Petrescu	Observatorul Astro-nomic Amiral Vasile Urseanu and out of the city of Bucureşti	SCT Meade 30 cm, f/10, QHY6 CCD	Directly
Arnaud Leroy	Observatoire OPERA	Newton 200 F/D 3.8	Remotely
Romain Montaigut	Bordeaux	+ CCD Atik 314 L+	
Infrared Telescope Facility	Big Island, Hawaii	IRTF 3m , spectrograph SpeX 0,7-2,5 microns	Remotely
Isaac Newton Telescope	La Palma, Canary Island	Telescop 2,5m f/15 spectrograph visible IDS	Remotely

3. THE RUNS

The runs occurred between April 11 and May 28, 2015. The schedule of these runs are presented in Table 2.

During the runs, the apparent movement in the sky for (7698) Romania was between the constellations Virgo and Libra (Figure 2). Thus, for an observer located over Romanian territory, the window of observation was for relatively tight. Indeed, during the opposition the asteroid was relatively close to the horizon. From the ephemerides we can see that the declination of (7698) Romania was in fact around -17° . In terms of topocentric horizontal coordinates, the maximum height of the object was less than 38° when passing to the meridian. However, the optimum window for observations was long enough to observe and record images of the asteroids thus deriving its astrometry.

The observations using telescopes located close to the Earth's equator, are more favorable while the object spent more time on the sky and its height when passing to meridian could be close to the zenith. Thus, the observations from Canary Islands and Hawaii were devoted to observations specific for computing its physical and mineralogical parameters.

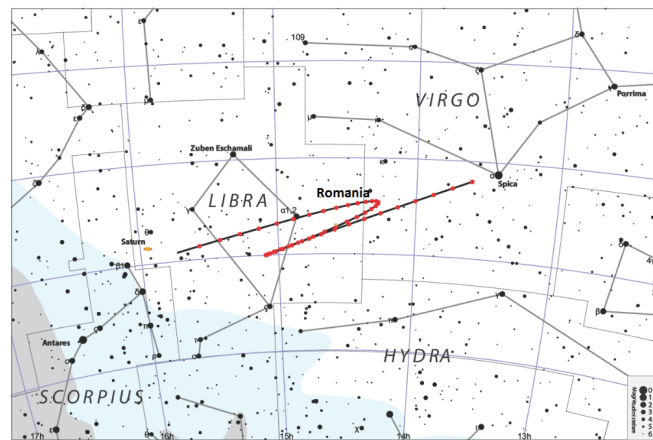


Fig. 2 – Apparent movement of asteroid (7698) Romania during its opposition, in May 2015.

Between April 11 and May 29, 2016 the observations were made for about 14 runs (Figure 3). Eight of these runs were performed in Romania, namely in Cluj Napoca, Bârlad, Vălenii de Munte, București. Six runs were made in Hawaii, New Zealand, Canary Islands, and France.

Table 2

Schedule of observations for asteroid (7698) Romania.

Date	Telescope and observer
28/29 May	Observatoire OPERA, Bordeaux Z97, observer Arnaud Leroy, Romain Montaignut;
23/24 May	Roque de Los Muchachos Observatory - Isaac Newton Telescope, observer Marcel Popescu;
22/23 May	Observatorul Astronomic din Bîrlad L22, observer Ciprian Vîntdevară;
19/20 May	Roque de los Muchachos Observatory din Insulele Canare, observer Radu Cornea;
16/17 May	Farm Cove E85, Noua Zeelandă, observer Jennie McCormick;
13/14 May	Farm Cove E85, Noua Zeelandă, observer Jennie McCormick;
11/12 May	Institutul Astronomic al Academiei Romîne A92, Bucureşti, observer Adrian Şonka;
9/10 May	Observatorul Astronomic Amiral Vasile Urseanu A92, Bucureşti, observer Elisabeta Petrescu;
6 May	Infrared Telescope Facility, Hawaii, observers Mirel Bîrlan/Marcel Popescu/Alin Nedelcu;
27/28 April	Observatorul Astronomic Amiral Vasile Urseanu A92, Bucureşti, observer Elisabeta Petrescu;
26/27 April	Star Dreams Observatory L16, Vălenii de Munte, observer Radu Gherase;
24/25 April	ROASTERR-1 Observatory L04, Cluj-Napoca, observer Lucian Hudin;
23/24 April	Observatorul Astronomic din Bîrlad L22, Bîrlad, observer Ciprian Vîntdevară;
10/11 April	ROASTERR-1 Observatory L04, Cluj-Napoca, observer Lucian Hudin;

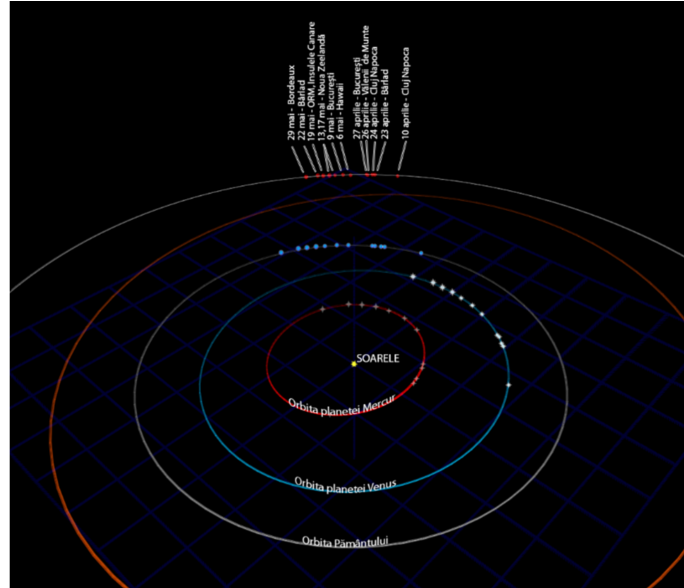


Fig. 3 – Overview of observational runs during the 2015 opposition. Sun and telluric planet orbits are represented in the graph. Each observational run is indicated on the asteroid Romanian's orbit.

4. PRELIMINARY RESULTS

Astrometric observations were recorded (Figure 4). The images were reduced and the astrometric positions were reported to Minor Planet Center. The astrometry was performed using NOMAD and UCAC-4 stellar catalogues.

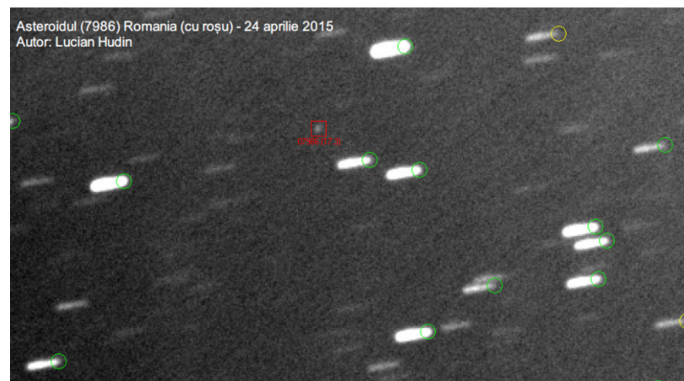


Fig. 4 – Stack of images of one field of stars containing the asteroid (7986) Romania. The asteroid is the dotted bright point in the center of the image while the stars are represented as trails. The images were recorded by Lucian Hudin in Cluj-Napoca, Romania.

Astrometry of asteroid is presented in Table 3 and it covers about 3% of its orbit.

Photometric observations were recorded using the 0.8m telescope owned by IAC in Canary Islands. The objective of the run was to derive the Romania's rotational period. This run covered three nights. Weather conditions were not adapted for doing absolute photometry. However, differential photometry allows for the first time an estimation of rotational period of (7698) Romania. The asteroid spins in approximately five hours as it could be seen in Figure 5.

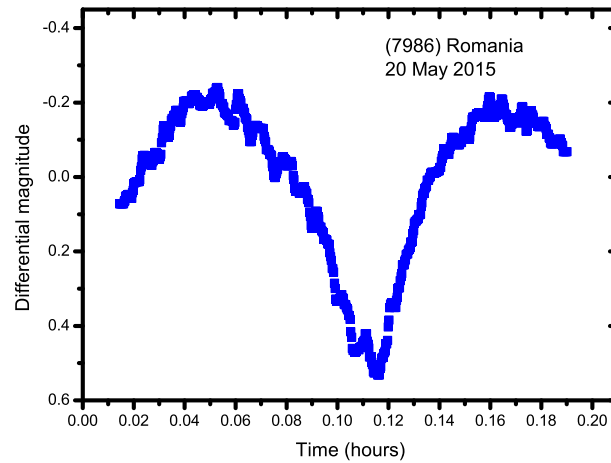


Fig. 5 – Lightcurve of asteroid (7698) Romania obtained during the night of 20 May 2015. Data were recorded by Radu Cornea using the 0.8m telescope owned by IAC in Canary Islands. Data reduction was performed using the pipeline developed by Vlad Tudor, trainee student to Isaac Newton Group of Telescopes.

Visible and near-infrared spectra were obtained using IDS spectrograph mounted on Isaac Newton Telescope and SpeX spectrograph mounted on Infrared Telescope Facility respectively. Both instrument maneuvers were performed remotely using ROC facilities (Birlan *et al.*, 2014). These observations together with mineralogical models derived from the composite spectrum, as well as the detailed analysis of photometrical data will be the subject of future articles.

Table 3

Astrometry of asteroid (7698) Romania

Date	Right ascension	Declination	Mag	Filter	UAI code	Reference
2015 04 10.98820	15 00 40.21	-19 38 13.2	18.1	V	L04	MPS 598747
2015 04 11.00117	15 00 39.73	-19 38 11.0	18.0	V	L04	MPS 598747
2015 04 11.01302	15 00 39.31	-19 38 08.9	17.8	V	L04	MPS 598747
2015 04 23.89919	14 51 03.16	-18 49 33.0	17.3	V	L22	MPS 603623
2015 04 23.90274	14 51 02.97	-18 49 31.2	17.1	V	L22	MPS 603623
2015 04 23.90627	14 51 02.76	-18 49 30.2	17.1	V	L22	MPS 603623
2015 04 24.89214	14 50 08.65	-18 44 39.3	17.9	V	L04	MPS 603623
2015 04 24.90549	14 50 07.91	-18 44 35.6	18.2	V	L04	MPS 603623
2015 04 26.002072	14 49 06.09	-18 39 01.9	17.8	V	L16	MPS 604839
2015 04 26.014700	14 49 05.35	-18 38 57.6	17.5	V	L16	MPS 604839
2015 04 26.016806	14 49 05.21	-18 38 56.9	17.4	V	L16	MPS 604839
2015 04 27.90781	14 47 16.89	-18 28 59.4	16.8	R	A92	MPS 604839
2015 04 27.91068	14 47 16.82	-18 28 58.2	16.6	R	A92	MPS 604839
2015 04 27.91354	14 47 16.59	-18 28 57.2	16.7	R	A92	MPS 604839
2015 04 27.91640	14 47 16.34	-18 28 54.9	16.7	R	A92	MPS 604839
2015 05 09.90722	14 35 15.11	-17 17 45.2	17.1	R	A92	MPS 614712
2015 05 09.92006	14 35 14.31	-17 17 39.8	17.1	R	A92	MPS 614712
2015 05 09.92575	14 35 13.97	-17 17 38.2	17.7	R	A92	MPS 614712
2015 05 12.85630	14 32 22.21	-16 59 13.8	16.8		073	MPS 612970
2015 05 12.87081	14 32 21.28	-16 59 08.1	16.5		073	MPS 612970
2015 05 12.89430	14 32 19.94	-16 59 00.0	16.6		073	MPS 612970
2015 05 13.43644	14 31 48.91	-16 55 23.5	17.6	R	E85	MPS 606507
2015 05 13.44911	14 31 48.15	-16 55 18.8	17.4	R	E85	MPS 606507
2015 05 16.38128	14 29 04.98	-16 37 03.4	17.4	R	E85	MPS 607496
2015 05 16.39209	14 29 04.36	-16 36 59.3	17.3	R	E85	MPS 607496
2015 05 16.39569	14 29 04.16	-16 36 58.1	17.3	R	E85	MPS 607496
2015 05 16.39931	14 29 03.93	-16 36 56.6	17.2	R	E85	MPS 607496
2015 05 16.41301	14 29 03.17	-16 36 51.8	17.2	R	E85	MPS 607496
2015 05 22.80759	14 23 45.33	-15 59 06.4	17.3	V	L22	MPS 608959
2015 05 22.81815	14 23 44.85	-15 59 02.3	17.6	V	L22	MPS 608959
2015 05 22.82870	14 23 44.39	-15 58 59.0	17.3	V	L22	MPS 608959
2015 05 22.83926	14 23 43.89	-15 58 55.2	17.6	V	L22	MPS 608959
2015 05 22.84981	14 23 43.39	-15 58 52.9	18.1	V	L22	MPS 608959
2015 05 27.88191	14 20 21.77	-15 32 06.7	16.6	R	Z97	
2015 05 27.92748	14 20 20.02	-15 31 53.7	16.6	R	Z97	
2015 05 27.97113	14 20 18.36	-15 31 39.3	16.9	R	Z97	

5. CONCLUSION

The observational campaign of (7698) Romania was successfully accomplished for the opposition of April-May 2015. Astrometry was reported to Minor Planet Center. We acquired photometric data which allow us to constrain the asteroid's rotational period of about 5 hours. Visible and Near -infrared spectra were also acquired and will be presented in future works.

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