Polarimetric Observations of NEAs at RTT150. First results.

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Abstract: *We present results of polarimetric and photometric observations of three faint NEAs with high proper motion in period of theirs close approaches: 276049, 333578 and 163132 performed at 1.5m Russian-Turkish telescope RTT150 in the end of August 2014. Due to that sources were observed at large phase angles from 40 to 100 degrees for different asteroids the measured linear polarization degree makes it possible to differentiate the taxonomy classes of observed sources even using single shot. The visual magnitudes and proper motions of asteroids are 16^m-17^m and 3"-10"/min. Assuming that the mean inverse angle is 20 degree we estimated slope parameter h and from well-known relation the albedo was calculated and together with present photometry we estimated the diameters of asteroids. Calculated albedos are 0.50±0.19 (E-type), 0.043±0.005 (C-type), 0.250±0.023 (S-type) and diameters are 0.306±0.08 km, 3.106±0.29 km, 0.221±0.03 km, respectively. The applications of new polarimetric device at RTT150 to the GAIA-FUN-SSO are discussed.*

1. Introduction

After the successful launch and calibration of space mission of European Space Agency GAIA the alerts on moving objects of Solar System are expected in the rate about 12000 per day (Tanga, 2015). Among of this large amount only a few will be new discovered. The aims of GAIA Follow-Up Network of Solar System Objects (GAIA-FUN SSO) which consist of 57 observing sites around the world are confirmation of newly discovered sources and improvement of orbits of critical targets. The identification of NEAs in frame of GAIA-FUN SSO has a special interest because they will be observed at different phase angles before the parameters of orbit will be determined with declared accuracy. In this context not only astrometry data but also photometry data of the Network together with additional polarimetric observations can be used for physical parameters estimations of newly discovered NEAs. The polarimetric study of physical properties of asteroids are based on well-known dependence of degree of linear polarization with phase angle (Belskaya and Krugly, 2015). We present results of polarimetric and photometric observations of three faint NEAs with high proper motion in period of theirs close approaches: 276049, 333578 and 163132 performed at 1.5m Russian-Turkish telescope RTT150.

2. Observation of NEAs

Polarimetric and photometric observations of selected numbered NEAs: 163132, 276049, 333578 were performed at RTT150 from 23 to 26 August 2014 in period of theirs close approaches. The criteria of selections are limited with brightness no faint than 17^m and with proper motion no more than 10 arcsec per min which is determined by the telescope performance. The phase angles of observations are 102˚, 71˚ and 39˚, respectively.

Polarimetric observations were performed in V-band on newly integrated into RTT150 observational system polarimeter TFOSC-WP based on the Wedged Double Wollaston (Helhel et al., 2015). The polarimeter makes it possible to measure polarimetric signals simultaneously in four polarization plane 0˚, 45˚, 90˚ and 135˚. So, the first three parameters of Stoke's vector S(*I,Q,U*) may be estimated and, correspondingly, degree of linear polarization and positional angle of polarization of sources may be determined. The working area of the polarimeter on FOV of the RTT150 is 1′ by 5′. Due to high proper motion of studied NEAs and its faintness the neighbour stars images distorts the polarization signals during exposure. To decrease this affect a set of 5 by 120 sec exposures was obtained using telescope facility of tracking with given trajectory. The combined image with median filtering is quite free from neighbour stars influence (Fig.1).

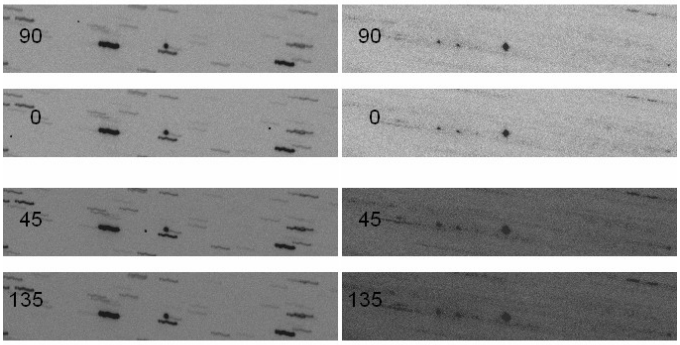

Fig. 1: TFOSC-WP image of 4 polarized beams at 0˚, 45˚, 90˚ and 135˚ separated by 60 arcsec of NEA 276049, V-band. Right is single 120 exposure image, left is result of combining of 5 images using median filtering.

3. Albedo, taxonomy and diameter estimations of selected NEAs

Dates of observations were corresponded to the large phase angles (102˚, 71˚ and 39˚, respectively). It allowed getting a good enough estimation of the geometric albedo p_v and differentiating asteroid on spectral complexes on the base of even single observation (Fig. 2).

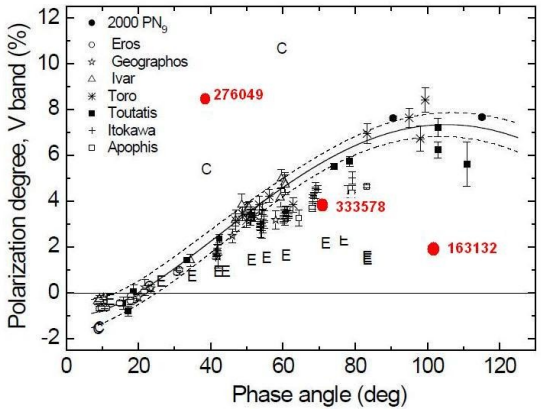

Fig. 2: Polarization phase curves taken from Belskaya et al. (2009) the measurements of polarization of asteroids of this work (red dots) has added.

As a result, we obtained the following values for the albedo and spectral classes in Table 1.

Table 1: Albedo and spectral type for observed 3 NEAs.

Name	Albedo	Spectral Type
163132	0.50±0.19	E-type
276049	0.043±0.005	C-type
333578	0.250±0.023	S-type

In estimations of albedo for 276049 and 333578 the relation *log*(albedo)-*log*(polarization slope) was used. The polarization slope was determined on the base of mean value of inverse angle α_{inv} of given spectral class (Mischenko et al., 2010) and measured degree of polarization on corresponding phase angle. For 163132 the fact that asteroid was observed in region of maximal polarization of phase curve was used and for albedo estimation the relevant relation *log*(albedo)-*log*(maximum polarization) was applied.

The photometric estimations in V-band: 16.80^m, 15.91^m and 17.00^m, respectively, were obtained with photometric accuracy about 1%. New *BV*, *VR* and *RI* color estimations of these asteroids: 0.56, 0.47 and 0.46 for 163132; 0.72, 0.37 and 0.39 for 276049; 0.81 and 0.63 for 333578 were obtained as well. With using mean parameter of photometric slope *G* for given spectral complex (Lagerkvist & Magnusson, 1990) and photometry, the absolute magnitudes *H* of studied asteroids were estimated. Thus, with known (p_v, *H*) diameters were estimated as in Table 2.

Table 2: Diameters for observed 3 NEAs.

Name	Diameter (km)
163132	0.306±0.08
276049	3.106±0.29
333578	0.221±0.03

The main source of uncertainties of the diameter estimations is uncertainty of photometric slope parameter *G*, which is necessary to specify observationally.

4. Conclusion

RTT150 is owner of new facility – polarimeter. Together with photometry and spectroscopy it gives promising results of NEOs physical parameters investigation. It was polarimetrically and photometrically observed three selected NEAs in period of theirs close approaches: 276049, 333578 and 163132. Albedos, taxonomy and diameters were estimated. Accuracy of diameters estimation is 10-20% even using single observation.

The NEA 276049 is well known asteroid with determined diameter as a 3.5 km by radar observation which is within of uncertainty of measured value 3.106±0.29 km. It is noteworthy, that measured physical parameters of the NEA 333578 close to potentially hazardous asteroid Apophis.

The newly discovered NEAs by Gaia will be observed by sites of GAIA-FUN SSO network. Recommended amount of frames for one set of observations is no less than 5 in R band. Investigation of physical parameters of NEAs may be successfully completed in frame of network photometric observations of astrometric alerts of GAIA (GAIA-FUN SSO) and polarimetric observations on RTT150. Due to that we suggest to observe Landolt standard stars before and after astrometric observations to make photometric calibration of asteroids.

ACKNOWLEDGMENT

The project for design polarimeter is completely financially supported by TÜBİTAK (Grand No. 113F263). This work was funded by the subsidy allocated to Kazan Federal University for the state assignment in the sphere of scientific activities.

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