PRACTICAL APPLICATION OF KNOWLEDGE BY ASTRONNOVIGATION FOR THE DISCOVERY OF NEW ASTEROIDS IN THE SOLAR SYSTEM

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Abstract. *In this article we introduce the training, the research work applied in the observational campaigns organized by the International Astronomical Search Collaboration, and the final results. Presented are the discoveries of 27 new asteroids, which are located in the Main asteroid belt between Mars and Jupiter.*

Keywords: *equatorial coordinates, astrometrical calculations, asteroids.*

1. Introduction

Astronavigation is one of the sciences, which are being assimilated in order to prepare the students for successful management of the vessels. Its purpose is to define the place of a ship and the corrections of the compass in open sea. Furthermore, the astronavigation uses the methods and results of the spherical and practical astronomy. That gives the opportunity to define the coordinates of some sky objects. The knowledge of these two sciences expands the knowledge and skills of the future captains, and causes a big interest and motivation for studying. The learning of the different astronomical coordinate systems and equatorial coordinate system gives the opportunity of solving a variety of practical astronomical tasks [1]. One of them is defining the coordinates of fast moving astronomical objects. Solving this task is in the base of a national program for searching, discovering and tracking of asteroids in the Solar system. For 3 months the students from the Astronomical student society at NVNA worked on the program IASC. After conducting the research on the astronomical images,

obtained from big telescopes in the USA, the equatorial coordinates of over 500 asteroids were defined and 20 more asteroids were discovered. The next steps in this work is the defining of their orbits. That way the students are learning to solve tasks regarding the determination of the coordinates of moving objects, initially on the sky, and after that in the marine areas of our planet.

2. Practical application of astronautical education

At the Naval Academy, Varna astronavigation is studied for 45 hours. In the process of learning, conclusions are being drawn from the theory of spherical astronomy, the visible movement of lights, systems for measurement of time, astronavigation tools and the theory of the astronomical observations, rules for performing the basic ways of determination of the coordinates of a ship and the repair of a compass. The students are expected to determinate the place of the ship and the repair of the compass by using tables and measuring equipment, and to work with a navigational sextant.

One unusual practical exercise is to determinate the coordinates of moving objects in the Solar system. For the solution of this task one needs to know the elements of the Solar system, the different coordinate systems, especially the equatorial coordinate system, and the process of obtaining and processing astronomical images [2]. In order to take part in the observational campaigns of IASC, the mastering of the professional astronomical software ASTROMETRICS is required. With its help, animations from a couple of astronomical images are created, flying objects are identified, new asteroids are found and their equatorial coordinates, right ascension and declination are defined. After that, a special report containing the full information of the results of the measurements and the made calculations is prepared and is sent to the IASC center, and after that it is sent to Minor Planet Center, Harvard University, Figure 1.

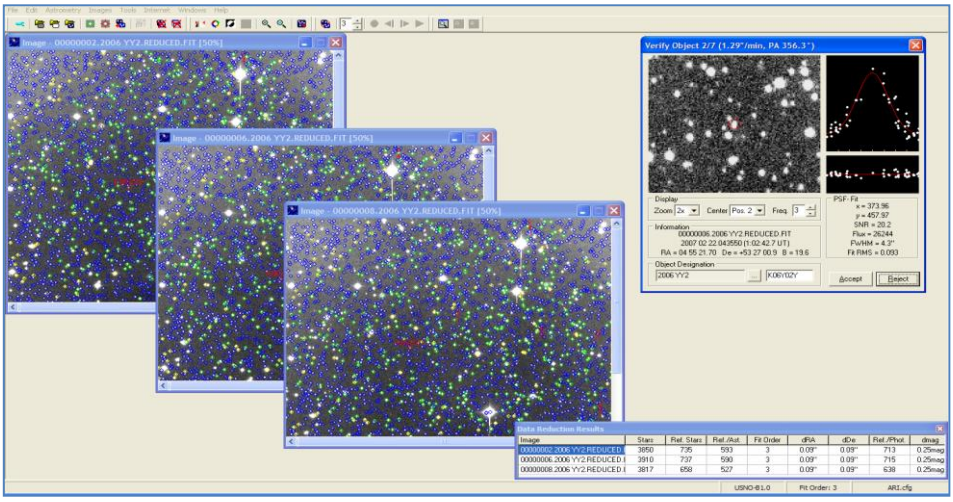

Figure 1. ASTROMETRICA – the professional astronomical software for detecting the asteroids and obtaining the equatorial coordinates

After processing the measurements, MPC sends information about any new objects found, and the obtained coordinates of known asteroids are used to define their orbits more accurately.

3. International Astronomical Search Collaboration

The International Astronomical Search Collaboration (IASC) is an educational outreach program for high schools, colleges and universities. It provides high quality astronomical data to students around the world. Students are able to make original astronomical discoveries and participate in hands-on astronomy. The research work of the students is organized into observational campaigns with a duration of 45 days. Observations for different companies are made by the big telescopes of Hardin-Simmons University (Abilene, TX), Lawrence Hall of Science (University of California, Berkeley), Sierra Stars Observatory Network (Markleeville, CA), Tarleton State University (Stephenville, TX), Yerkes Observatory (University of Chicago), Pan-STARRS (Institute for Astronomy, University of Hawaii), Faulkes Telescopes Project (Wales), G.V. Schiaparelli Astronomical Observatory (Italy), Western Kentucky University (Bowling Green, KY), Target Asteroids! (University of Arizona), Mt. Lemmon SkyCenter (University of Arizona), Las Cumbres Observatory Telescope Network (Santa Babara, CA), Catalina Sky Survey, University of Arizona. The biggest telescope used to receive astronomical images is the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS). Pan-STARRS located at Haleakala Observatory, Hawaii, consists of astronomical cameras, telescopes and a computing facility that is surveying the skyfor moving objects on a continual basis, including accurate astrometry and photometry of already detected objects. Students from the Student Astronomcal Society and the Student Space Society by

Nikola Vaptsarov Naval Academy have passed theoretical and practical training with regards to working on the researching program, carried out by the astronomer in the Planetarium of the Naval Academy, ass. Prof. Dr. Veselka Radeva.

4. The work of the student astronomical society in the observational campaigns of International Astronomical Search Campaigns

From the 19th of May to the 17th of June 2017, the students took part in two observational campaigns: Bulgaria-Luxembourg Asteroid Search Campaign and International Asteroid Search Campaign. From 17th June to 15th July 2017 the students participated in the International Asteroid Search Campaign. From 16th July to 15th August 2017 the students participated in the International Asteroid Search Campaign. Along with the Bulgarian students, many other students from universities around the world took place in these campaigns. During the campaign, astronomical observations with professional telescopes were made. The received astronomical images were placed in the web-pages of the teams. The students downloaded the images, worked on them using the astronomical software Astrometrics, found the moving objects, defined the vector coordinates and prepared a report for Minor Planet Center Figure 2.

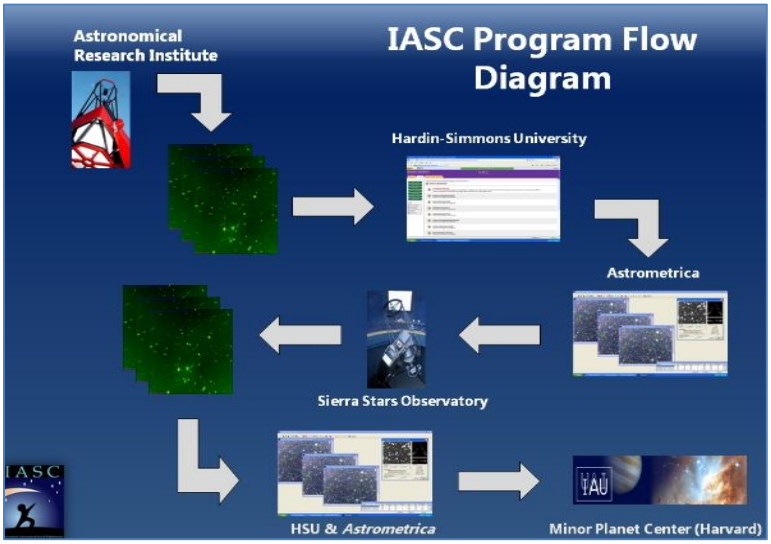

Figure 2. The process of detecting moving asteroids

The reports were sent to the leader of the Bulgarian teams Dr Radeva, who checked the accuracy of the measurements and only then the reports were sent to the Program Center. During a single campaign, a few dozen astronomical images were processed.

5. Results from the research of the astronomical images.

In the three campaigns, held in the months of May, June, July and August, the following students took part – Anton Dimitrov, Marian, Dimidov, Georgi Vidolov, Adriana Ivanova, Dimitar Traev, Svetoslav Georgiev and Konstantin Nikolov. The results of the three observational campaigns are listed in Table 1. A total of 360 astronomic images were processed. The equatorial coordinates, right ascension and declination of 1720 asteroids were determined, and in this way their orbits around the Sun were refined. 27 new asteroids were discovered, located in the main asteroid belt between Mars and Jupiter. More observations are required to calculate the orbital elements of the new asteroids. After determining the orbital elements of the asteroids, the opportunity to name each of the discovered asteroids will be given to the discovery team. The new asteroids initially receive provisional names containing letters and numbers such as "P10Bqf0".

In Table 1. are listed the following: the number of astronomic images processed, the number of known asteroids for which the equatorial coordinates were established, the newly found asteroids, the dates of their discovery and their discoverers.

Table 1. Results from the Asteroid Search Campaign held from 19 May to 17 June, 2017.

Observational Campaign	**19 May – 17 June 2017**		**17 June – 15 July 2017**	**16 – 15 August 2017**
	Bulgaria-Luxembourg	**International Asteroid Search Campaign**	**International Asteroid Search Campaign**	**International Asteroid Search Campaign**
Processed images	100 images	100 images	96 images	64 images
Famous asteroids, whose coordinates were measured	500 known asteroids	500 known asteroids	400 known asteroids	320 known asteroids
Main Belt Asteroid Discoveries New Asteroids Preliminary discoveries	1. P10Bqf0- 05/19/17 2. P10BqfR - 05/19/17 3. P10Bqmr - 05/19/17 4. P10Bqqf - 05/19/17 5. P10Bqqr - 05/19/17 6. P10Bqui - 05/19/17 V.Radeva, M.Dimidov, K. Nikolov & A. Dimitrov 7. P10Bpvi - 05/19/17 8. P10Bgfv - 05/19/17		1. AZD0001 –06/21/17 2. AZD0002 - 06/21/17 V.Radeva, M. Dimidov, G. Vangelov, A. Dimitrov 3. AZD0074 - 06/21/17 4. AZD0075 - 06/21/17 5. P10BDuY - 06/21/17 6. P10BDyf - 06/21/17 7. RDD0001 - 06/21/17 8. RDV0003 - 06/21/17	There aren't new asteroids in the images

	9. P10Bqmq - 05/19/17 V. Radeva, A. Dimitrov & M. Dimidov 10. P10BrZa – 05/21/17 11. P10Bs55 - 05/21/17 V.Radeva, M. Dimidov, K. Nikolov & A. Dimitrov 12. P10Bx2x – 05/27/27 13. P10BxDa - 05/27/27 14. P10BxmN - 05/27/27 V.Radeva, M. Dimidov, A. Dimitrov 15. P19BxAW- 05/27/27 V.Radeva, A. Dimitrov 16. P10BxGu - 05/27/27 17. P10BxNc - 05/27/27 18. P10BxoZ - 05/27/27 19. P10BxDs - 05/27/27 V.Radeva, M.Dimidov & A. Dimitrov	V.Radeva, M. Dimidov, G. Vangelov, A. Dimitrov	

Conclusion

The participation of the students in the International Asteroid Search Campaigns helped them to further develop their astronomical knowledge after undertaking an Astronavigation course. In addition, they gained ability to use professional astronomic software. The result of their research was the finding of 27 new asteroids located in the Solar System. The processing of the results greatly motivated the participants and encouraged them to expand their skills beyond their curriculum, thus increasing the quality of their education.

References:

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