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International Astronomical Search Collaboration: An Online Outreach Program in Astronomical Discovery for High School & College Students

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Abstract
The International Astronomical Search Collaboration was founded in October 2006 at Hardin-Simmons University in Abilene, TX. This is an online educational outreach program, in which high school and college students make original discoveries of Solar System objects; such objects include near-Earth objects, Main Belt asteroids, Trojan asteroids, Centaurs, trans-Neptunian objects, and comets.Images from professional observatories are provided online to the participating schools. Students download these and use the software Astrometrica to search for, discover, and measure these objects. The student observations and astrometric measurements are validated, then submitted to the Minor Planet Center at Harvard University. To date, there have been 1311 submissions of new objects not yet confirmed with subsequent observations, and 50 that are confirmed as new objects, numbered and named by their student discoverers.

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Introduction

The International Astronomical Search Collaboration (IASC, pronounced "Isaac") was founded in October 2006 at Hardin-Simmons University in Abilene, TX (Miller et al., 2008). The program began with 20 schools from 3 countries. A total of 140 students participated. During the current 2016-17 academic year, the program has grown to 700 schools in 80 countries. In 2017-18 it will grow again to 1,000 schools reaching 7,000 students. Table 1 shows the growth of IASC since its inception in 2006.

IASC is not, despite its appearances, an asteroid discovery program. It is an online educational outreach program made available to teachers. IASC focuses on making sure the service works when they need it and that it is easy to integrate into their classrooms. To a large extent, even the teachers are organized by one of the numerous organizations that IASC works with.

Figure 1 shows the IASC logo. Figure 2 shows the ethnic distribution of the participating students. It is important to note that Indian refers to the country of India, and not Native American Indians.

Students make original discoveries of objects within the Solar System. To date these discoveries include:

- 1245 provisional Main Belt asteroids (MBAs)
- 48 numbered MBAs
- 5 provisional trans-Neptunian objects (TNOs)
- 2 numbered TNOs
- 10 near-Earth object (NEO) provisionals (PHA 2009 BD81)
- 1 Jupiter-family comet (276/P Vorobjov)

Academic Year	# of Schools	# of Students	# of Countries
2006-07	20	140	3
2014-15	300	2,100	50
2015-16	500	3,500	60
2016-17	700	4,900	80
2017-18	1,000	7,000	80

Table 1. *Growth of IASC since 2006.*

The numbered objects are cataloged by the International Astronomical Union (IAU, Paris). Names have been proposed to the IAU by their student discoverers. The process to move from a provisional designation to a numbered or named designation takes on the order of 6 to 10 years (to capture the majority of the orbit), so this is not a direct or swift process.

Figure 1. *IASC logo designed by Matthew Davis.*

Search Campaigns

IASC works with 15 organizations around the world which organize schools and teachers who participate in the campaigns. The year is divided into 7 search campaigns timed with the 3rd quarter Moon. Each search campaign is made up of multiple entities, the majority of them are regional (e.g. India or Iran), although some can be international in focus as well as a special 'Asteroid Day' campaign. From 3rd to 1st quarter (through the new Moon) IASC receives images from professional observatories. These are partitioned and distributed to 100 schools in each campaign, with each school receiving its own unique set. The online distribution site is found at http://iasc.hsutx.edu. The schools have 30 days until the next 3rd quarter to analyze the images.

Students use the software Astrometrica to search for discoveries and make astrometric measurements[1]. The measurements are sent as text file attachments in an email to IASC at iascsearch@hsutx.edu. IASC validates the student observations and submits the measurements to the Minor Planet Center (MPC)[2].

A total of 700 schools from 80 countries participate. For academic year 2017-18, this number has been increased to 1,000 schools. Each school gets allocated their own unique set of data. IASC will reach 7,000 students in the coming academic year. Figure 3 shows students from a school in Morocco displaying their certificates from their participation in a 30-day IASC campaign.

Collaborators

There are two major observatories currently within the IASC collaboration:

- Panoramic Survey Telescope & Rapid Response System (Pan-STARRS) Institute for Astronomy University of Hawaii Honolulu, HI

[1] www.astrometrica.at
[2] www.minorplanetcenter.net/iau/mpc

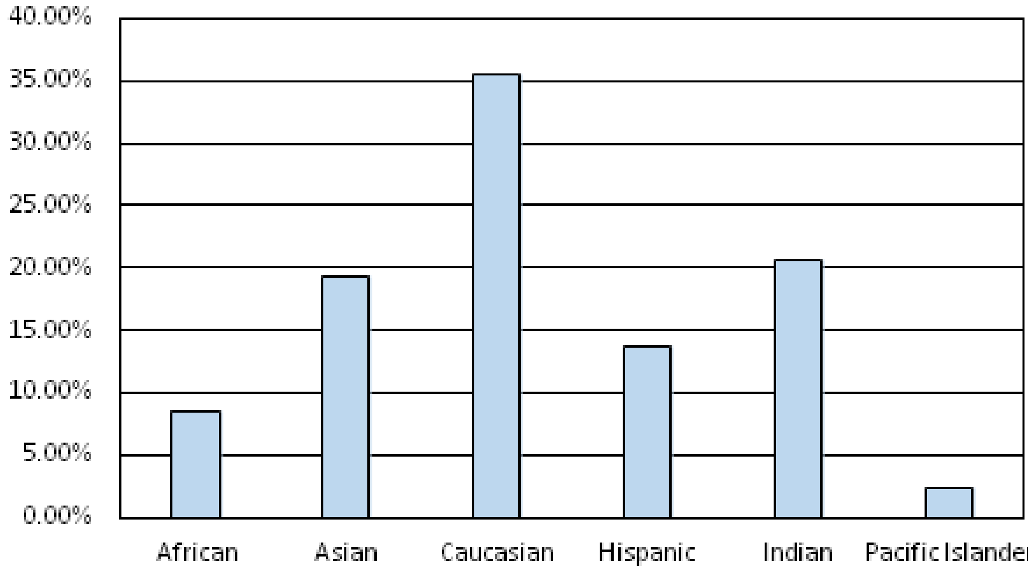

Figure 2. *Current ethnic distribution of participating students in IASC.*

- Catalina Sky Survey (CSS) Lunar & Planetary Laboratory University of Arizona Tucson, AZ

Pan-STARRS (Chambers et al. 2016 and Magnier et al. 2016) has the 1.8-m PS1 and PS2 telescopes located on Haleakala, Maui. Attached to Pan-STARRS is the world's largest CCD camera that covers 7 deg2 fields, each containing 1.4 Gpx. In a campaign with 100 schools, IASC receives 12 images from PS1 that are partitioned into 2,496 sub-images (208 per image) and distributed to the schools. Each school receives 24-25 sub-images to analyze using Astrometica.

In each image students will observe 150 MBAs, 20 of which were not detected the by the PS automated pipeline. In every 6th image, there is an NEO not detected by the pipeline. This is based on experience with the datasets so far analyzed since 2010.

CSS (Larson et al., 2003) has the 1.5-m G96 telescope located on Mt. Lemmon outside of Tucson, AZ. Attached is a 10K x 10K camera that produces 5 deg2 fields (2x2 binning). Each image is partitioned into 4 sub-images. A campaign with 50 schools will use 313 images, providing 25 sub-images per school to analyze.

In each of the CSS images students will observe 1 MBA every 4th image that is not detected in the automated pipeline. The number of undetected NEOs is not currently known as the CSS campaigns only started in May 2017. As additional campaigns are conducted, the rate of undetected NEOs per image will be measured.

The amount of data that is accessible to the IASC project from these two observatories is practically limitless compared to the number of schools and campaigns that could be run. With facilities such as LSST (LSST, 2017) coming up on the horizon and other large-scale continuous surveys, data is definitely not a limiting factor in scaling up the project.

In the past, the following facilities have also provided images for student search campaigns:

- Astronomical Research Observatory[3] 1.27-m Astronomical Research Institute Westfield, IL
- Las Cumbres Observatory (Brown et al., 2013) 2-m Faulkes Telescope Haleakala, HI
- Las Cumbres Observatory (Brown et al.,

[3] www.astro-research.org/observatory_directory.htm

Figure 3. *Students from Morocco displaying their IASC participation certificates. Photograph provided by IASC.*

2013) 1-m Sutherland Telescopes South Africa

- Sierra Stars Observatory Network (Williams and Beshore, 2011) Mt. Lemmon Sky Center 0.81-m Schulman Tucson, AZ

The Astronomical Research Observatory (ARO) participated in IASC from 2006-2015 and was one of the initial telescopes used in the project. The 0.81-m and 1.27-m prime focus telescopes were used to provide >10,000 images to the schools. Once 200 schools were reached, this essentially took all of the observing time available on these telescopes. Figure 4 shows the 1.27-m telescope at the ARO. The LCO telescopes and Sierra Stars Observatory Telescopes have been, and continue to be, used for follow-ups of particularly interesting asteroids.

Using the 0.81-m Schulman telescope at the Mt. Lemmon Sky Center, one comet discovery (276/P Vorobjov) was made. Tomas Vorobjov from Slovakia is a recipient of the 2013 Edgar Wilson Award for this discovery[4]. See Figure 5 for an image of 276/P Vorobjov.

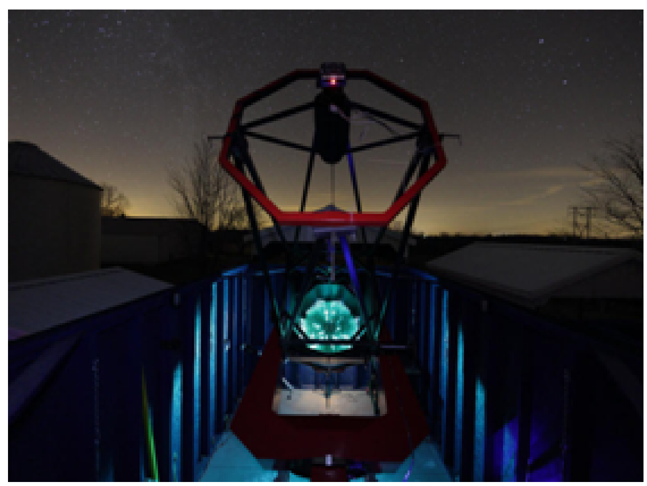

Figure 4. *The 1.27-m prime focus telescope at the Astronomical Research Observatory. Photograph by the Astronomical Research Institute.*

5-Year Growth Plans

During the next 5 years, IASC will move to a cloud-based delivery platform. The platform will be used to store and distribute the image sets to the participating schools. As a result, this move will

[4] www.cbat.eps.harvard.edu/special/EdgarWilson1

Figure 5. *Stack of 4x40s images tracked on the motion of 276/P Vorobjov. Photograph by Andrea Boattini (G96) on October 17, 2012.*

allow the expansion to 2,500 schools with 500 from the United States. Previously, multiple sets of gigantic files had to be moved manually across multiple sites via ftp for processing.

A discovery portal for the general public will be established that allows up to 10,000 citizen scientists to participate. The purpose of the portal will be the detection of NEOs missed by the Pan-STARRS and CSS automated pipelines.

A new search program will be established that includes the discovery of TNOs. To date 7 TNOs have been discovered by participating students, 6 from Pan-STARRS and 1 from the Astronomical Research Observatory. Pan-STARRS images will be distributed to the 2,500 schools and in the discovery portal to the 10,000 citizen scientists. In addition to TNOs, there will be discoveries of Centaurs and perhaps incoming comets among the outer planets.

Under development are distribution methods that are alternative to schools. One program is for students and the general public to make MBA discoveries while attending planetarium shows. The planetarium approach is to project images from Pan-STARRS and the CSS onto planetarium domes and the audience look for asteroids in blinked images. The operator then makes the measurements of the objects that were seen. Using Astrometrica the students and the general public will search for, discover, and measure MBAs. In October 2017, a pilot test with 1,300 students from Midland-Odessa, TX is being run at the Marian West & William Blanton Blakemore Planetarium.

In support of Asteroid Day 2018, IASC and Astronomers Without Borders[5] will collaborate to find 50 sites around the world to set up events for the general public to search through Pan-STARRS images to make MBA discoveries. IASC tested this concept in one Asteroid Day 2017 event in Brazil. A total of 70 sub-images were provided, and throughout the day the general public participated to make discoveries.

Recruitment and Support of Teachers and Teams

Table 2 shows many of the astronomy education outreach programs that recruit and train teachers to participate in the IASC search campaigns. Also included are amateur astronomy groups that recruit and train teams.

IASC also provides online assistance to answer questions and process the student astrometric measurements. This assistance is primarily by email but, on occasion, includes video conference. The following staff currently field many of the inquiries:

- Cassidy Davis, IASC Coordinator
- Denise Rothrock, Madisonville High School (Texas)
- Ginger Anderson, May High School (Texas)

Denise Rothrock and Ginger Anderson are high school physics and astronomy teachers. They have participated in IASC search campaigns since Fall 2008, and answer multitudes of questions by

[5] www.astronomerswithoutborders.org

Recruiting Organization	Country
Astronomers Without Borders	Worldwide
Space Generation Advisory Council	Worldwide
Haus der Astronomie	Germany
Nojum Magazine	Iran
Núcleo Interactivo de Astronomia	Portugal
Secondary Council of Schools	Uruguay
Astronomy Association of the State of Lara	Venezuela
Space Popularization of Communicators & Educators	India
China Hands-On Universe	China
Luis Cruls Astronomy Club	Brazil
Center for Theoretical Physics	Poland
Astronomical Observatory & Planetarium, Varna	Bulgaria
Astronomical Society of South Africa	South Africa
Al Akhawayn University	Morocco
Target Asteroids!	Worldwide
Global Hands-On Universe	Worldwide

Table 2. *Organizations that recruit and train teachers and amateur astronomy teams.*

teachers and students during each of the search campaigns. To get involved, navigate to the IASC site[6] or email: iascsearch@hsutx.edu.

The search campaigns are provided at no cost to the participating schools or to the astronomy organizations that recruit and train the teachers and amateur astronomy teams. The software Astrometrica is provided at no cost for use in IASC by its author Herbert Raab. The images distributed to the schools by the observatories are donations in support of this international astronomy outreach program for high school and college students.

The IASC program is not prescriptive of how the data, tools and approach are used. There is a heavy reliance on teachers to integrate the program into their classroom. Different teachers do it different ways. Some teachers, first thing in the morning, for a class of 30 students go through all of the images with their class. Other teachers will wait until lab time and get smaller groups of students look at it. Typically, classes start off very enthusiastic searching for asteroids and the first few days of a campaign many reports from students will be received. By the end of the campaign the class would be narrowed down to 2 or 3 students who have a particular interest still participating.

[6]iasc.hsutx.edu/

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