Education and Heritage in the era of Big Data in Astronomy
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Galaxy Forum South America-Argentina 2020

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Abstract. Galaxy Forum (GF) South America 2020, was held virtually on December 8, 2020 on the opening eve of IAU 367 by the International Lunar Observatory Association (ILOA Hawai'i) with the support of the Instituto de Tecnologías en Detección y Astropartículas (ITeDA, CNEA-CONICET-UNSAM) and IAU. Galaxy Forum is an education and outreach program sponsored by ILOA, an interglobal enterprise incorporated in Hawaii as a non-profit organization to expand human knowledge of the Cosmos through observation from our Moon and to participate in internationally cooperative lunar base build-out.

As a IAU-367 associated event, Galaxy Forum featured comments by Dr. Beatriz Garcia and presentations by ILOA Director Steve Durst (ILOA Hawai'i, USA), Marcelo Colazo (CONAE, Argentina); César Gonzalez García (CSIC, Spain); Li Geng (NAOC, China); Santiago Paolantonio (Córdoba Observatory, Argentina) and Margarita Safonova (IIA, India). In this contribution, the overview of the contributions permits an approach to the GF interests.

Keywords. astronomy education, history of astronomy, astronomy from the Moon

1. Astronomy from the Moon, Precession, Epochs and 21st Century Astronomy, presented by Steve Durst

Earth axial precession, called "Earth's 3rd Motion", is the geo-dynamic process which results in the Sun appearing from Earth at any equinox to move counter-clockwise on the ecliptic through constellations of the zodiac: The Precession of the Equinoxes. Through evolving 21st Century techniques (such as VLBI and astronomy from the Moon), accurately observing the Earth's rotation/precession may help more precisely determine the apparent arrival of the Sun on the ecliptic in the constellation of Aquarius at the time of the vernal equinox, which is now calculated about 2597 AD using the IAU 1928/current map.

With the approach to J2000.0/New Millennium from the 1960s/1970s especially, astrophysics and astrometry scientists have been focusing intensely on Earth precession rates and expressions.

Work on Precession and Rotation of the Earth has accelerated since 1930, when the 88 constellations and their boundaries - fixed by Delporte along strict lines of declination and right ascension as they existed at epoch 1875.0 – finally became ratified and published by the International Astronomical Union (IAU). We will also discuss our efforts to form a Working Group with the focus on Earth Precession, Constellations and Epochs.

2. History of Constellations and the *Uranometría Argentina*, presented by Santiago Paolantonio

The current astronomical community unanimously accepts the division of the celestial sphere into 88 constellations, according to what was established by the International Astronomical Union. After the formation of the Union, in the first Assembly of 1922 the exclusive use of the Latin names for the constellations and their abbreviations was resolved with the three letter system. In the following meeting, the Belgian National Committee of Astronomy examined the pending issue of the limits of the constellations, presenting a motion to review them. The astronomer Eugne Delporte was given the responsibility of the complete theoretical demarcation. In his work presented in 1930, to define the constellations and their limits, Delporte took especially into account what was done half a century earlier in the famous work of the Uranometría Argentina (Paolantonio & Garcéa 2019) of the *Observatorio Nacional Argentino* (1877–1879).

The reason for using the *Uranometría Argentina* was based on the fact that in this work a detailed investigation was made of the current situation at that time, unifying the stellar denominations and solving a proposal of the limits of the constellations, which used arcs of right ascension circles and parallels of declination, choosing them in such a way that they did not deviate too much from those used in the most important atlas of the time, and minimizing the changes of belonging of the stars to the constellations.

Delporte opted to use the reference equinox of 1875.0, to coincide with the for the Southern Uranometry in order to form a set with it, although by that time the positions were already given referred to 1900.0. For the maps that accompanied the report, the projection chosen in the *Uranometría* were defined taking as reference the proposal made in the *Uranometría Argentina*.

3. Prospect for UV Observations from the Moon: the Journey of LUCI, presented by Margarita Safonova

For every human endeavor, there are always people asking 'WHY?' Why going to space, when we can observe safely from the ground? Why going to the Moon, when we can observe cheaper from the near-Earth orbit? It happened before: "Space travel is utter bilge", claimed Richard van der Riet Woolley on assuming the post of British Astronomer Royal in 1956 (Wolley 1956). On the eve of the Apollo 11 landing, he insisted that "from the point of view of astronomical discovery, it [the Moon landing] is not only bilge but a waste of money" (Wolley 1958). 50 years later, the referee of the LUCI paper asked why do we need to go to the Moon, why can't we launch on a CubeSat, or even suborbital flight? And the reason for going to the Moon was not only because observing from the ground, or from near-Earth orbit, is becoming more and more problematic: up to 25,000 small satellites may be launched by 2026, with additional 42,000 SpaceX Starlink satellites, making night sky opaque for astronomy; while the amount of man-made orbital debris becoming unmanageable. ESA Space Debris Office estimates (as of November 2020) more than a million debris objects larger than cm size and 128 million objects in 1 mm to 1 cm range (ESOC 2020).

Our main reason was that we had an opportunity to do astronomy from a frontier, due to the Team Indus, an Indian contestant for the Google Lunar X PRIZE competition MoonShot, who offered to mount LUCI on their lander as a transit telescope to perform

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a survey of the available sky from the surface of the Moon. Our choice was for the UV telescope, because the Earth's atmosphere absorbs and scatters UV photons preventing observations of the active Universe. UV-emitting phenomena are generally associated with high-energy activity: massive star formation, hot transients such as supernovae (SNe), which stay UV bright for hours to days, AGN flare M-dwarfs with UV-flaring activity, and flashes from cosmic collisions. The UV range is a critical tool for classifying and studying these hot transients, and the Moon presents unprecedented platform for UV astronomy especially, with essential absence of atmosphere and ionosphere offering an unobstructed view of the space, and low gravity as a stable platform for telescopes.

Lunar Ultraviolet Cosmic Imager (LUCI) is a near-ultraviolet (NUV, 200–320 nm) all-spherical mirrors imaging telescope for transit astrometry from the lunar surface. Though the launch was cancelled, there are currently several initiatives in place and LUCI is an innovative telescope designed to take advantage of these opportunities. LUCI 0.5° field of view (FOV) and a weight of only 1.2 kg makes it unique. No other UV space payloads have been previously reported with an all-spherical optical design for imaging in the NUV domain and a weight below 2 kg. Another unique feature is the high brightness limit – LUCI can observe bright UV sources not accessible by the more sensitive large UV missions. The processing and analysis of the data is intended to be performed by the students and to be open to the public as soon as the processing is done. Thus LUCI can be straight away engaged in the citizen science program that we plan to start at the Institute.

We are continuing with our space instruments development, and have designed and built a wide-field NUV Transient Surveyor (NUTS) that can be flown on a range of available platforms: CubeSats, larger space missions, or even go to the Moon (Mathew *et al.* 2019). NUTS is a Ritchey-Chrétien (RC) telescope with a solar-blind photon counting detector and an FPGA-based processing unit. The 3° FOV is especially intended for performing transient survey of the UV sky. NUTS is fully assembled and calibrated, and is stored along with LUCI in a class-100 facility. As LUCI and NUTS are fully developed and ready to fly, they can demonstrate the diverse science capabilities of Moon-based, small, low-cost UV payloads.

4. CONAE's Activities Related to Deep Space Stations, presented by Marcelo Colazo

The National Commission for Space Activities (CONAE, https://www.argentina.gob.ar/ciencia/conae) is the Argentine Space Agency with the capacity to act publicly and privately in scientific, technical, industrial, commercial, administrative and financial matters, as well with competence to propose policies for the promotion and execution of activities in the space area for peaceful purposes. With this objectives, CONAE must propose and execute a National Space Plan, considered as a State Policy, to use and take advantage of science and space technology for peaceful purposes and provide information to the country in order to collaborate in an effective government management.

Within the framework of the intergovernmental agreement signed between the People's Republic of China and the Argentine Republic, the subsequent Amendment to the aforementioned agreement signed, and the inter-institutional agreements signed between the National Commission for Space Activities (CONAE), China Launch and Tracking General Control (CLTC), and the Province of Neuquén, the CLTC – CONAE-NEUQUEN Station was established to provide support to the Chinese lunar exploration program. In the same way, the European Space Agency (ESA) and the government of the Argentine Republic through CONAE, signed in 2009 an agreement for the establishment of the station called ESA Deep Space 3 (DSA3,) in the city of Malargue, located in Mendoza province to support European interplanetary exploration space missions.

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The agreements allow the use of 10% of the operational time of the stations for CONAE and its projects in cooperation with national and international partners. The installed technology allows not only monitoring and telecommunication with spacecraft, but also scientific research projects. Our country promoted the possibility of using these facilities for space and scientific activities. Several scientific institutions in the country have been working together in radio astronomical projects as continuum observations of radio sources and the Sun using the original backend instruments located at the stations since 2015. In order to make effective use of the time available, in 2019 CONAE opened a call for research opportunity addressed to the national scientific community. Seven projects were presented that cover the entire time available, in which the Argentine Institute of Radio Astronomy (IAR) and other institutions of the country's astronomical community participate, to begin working in the coming months.

By 2021 CONAE, in collaboration with IAR and the Institute of Technologies in Detection and Astroparticles (ITeDA), plans to finish manufacturing and putting into operation an Argentine instrument for scientific use that will take full advantage of the capabilities of the stations.

5. Picturing the Skies in Ancient China, presented by Geng Li

This contribution is a review of astronomy and culture in ancient China, as well as a prospect of historical astronomy research. It was commonly known by ancient Chinese people since very early ages that stars appeared in the sky can indicate seasons. Patterns of groups of stars from the Neolithic ages inferred that observations have been made at that time. The constellations in China were called "asterism", associated with royal governance and human society under the philosophical idea of "correspondence between heaven and man" (Xiaochun & Kistemaker 1997).

This idea also resulted in continuous celestial phenomenon records among the past two millenniums. More than 38,000 items concerning sunspots, eclipses, historical supernovae and novae, comets and meteor showers, auroras that could help us to track back to the historical skies. Despite the purpose of the ancient Chinese observers was not on scientific research, it has been an indispensable legacy for us to uncover the mystery of the universe, not only for astrometric but also astrophysical approach. From the star atlas and star catalogues, we could possibly extract useful astrometric information. An online database called "Ancient Chinese Astronomical Phenomenon Catalogue (ACAPC)" is under construction and will be launched in the near future. Hopefully, this effort can make better understanding beyond the boundary of science and humanities.

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