THE ARECIBO OBSERVATORY EXPLORING THE SPACE FROM PUERTO RICO





Dr. Alessandra Abe Pacini – Arecibo Observatory – June 25th, 2018.



- Brazilian Physicist (2004 SP)
- Master in Space Geophysics (2006 SP/Brazil)
- PhD in Space Geophysics (2010 SP/Brazil)
- PhD² in Physical Sciences (2015 Oulu/Finland)
- Undergrad/grad professor (+10 years)
- Girls InSpace writer



Who am I? (Pacini, A.A.)

- Married with another nerd: Jon Fentzke
- Mom²: Gabriel (6) and Aurora (1).
- AO scientist and lover 💙



What do I study?



HELIOPHYSICS

Solar Activity / Solar Flares / CMEs

- Solar Corona, Solar Wind, IMF
- Solar modulation of energetic particles (cosmic-rays / SEPs) transport
- Space Weather (at Earth and Solar System planets/moons)
- As applied to other stellar-planets systems



Why am I here?









The Arecibo Observatory – idea/context



Bill Gordon

Cold War!

In 1958, Arecibo was designed to study radar scattering in the ionosphere – military spy weapon: satellites, missiles, radio communication!

Equatorial and natural limestone depression.

Space exploration race! NASA - 1958

The Arecibo Observatory – idea/context



Understand the ionosphereis fundamental for trans-ionospheric and sub-ionospheric radio communications.



The main source of ionospheric anomalies is the Space Weather!



The AO 3-yr construction!



Since: Nov 1st, 1963.

Route 625 Bo. Esperanza, Arecibo – Puerto Rico (18.35° N, 66.75° W)

SAS – Astronomy – Planetary Operations, Electronics, Maintenance, and Visitor Center



ARECIBO OBSERVATORY PUERTO RICO UCF · YEI · UMET

305m (1,000 feet) diameter spherical single-dish antenna.

Largest single dish for 50 years World's most sensitive ISR Incoherent Scattering Radar

Unique cluster of instruments (radio passives and actives)

Diversity in the Science Staff on site: gender, nationalities, backgrounds International collaborations







Radio waves from (and to) space





Radar Station



Radio Astronomy

Pulsars Quasars Extragalactic NANOgrav VLBI

+ UPR/Arecibo (Prof. Abel Mendez – Exoplanets)



Nipuni Palliyaguru

Kristen Jones

The high sensitivity of the Arecibo radio telescope allows astronomers to detect faint radio emissions from far-off regions of the universe. **The second fastest known pulsar** – the first millisecond pulsar to be found – **was discovered at Arecibo**, as were the **first exoplanets**, which were found orbiting a pulsar. The **1993 Nobel Prize in Physics** was awarded to Russell Hulse and Joseph Taylor for their work with Arecibo in monitoring a binary pulsar, providing a strict test of Einstein's Theory of General Relativity and the first evidence for the existence of **gravitational waves**. Today, pulsars are being used to directly search for gravitational waves through incredibly accurate timing with the Arecibo telescope.

Planetary radar

Arecibo is a unique radar capability for Planets, moons, asteroids and comets. – **NASA grants.** The weak radio echo is collected, focused and detected by the Arecibo Telescope: information about the surface roughness, composition, size, shape, rotation and path of the target object. The Arecibo Radio Telescope has been used to measure the rotation rate of Mercury and to generate surface maps of large areas on Mercury, Venus and the Moon, locating mountain ranges, craters and rift valleys. **The first detection of radar echo from a comet was made at Arecibo.**



The Arecibo Observatory SAS – Space and Atmospheric Sciences



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Education & Public Outreach



n collaboration with the Caribbean Astronomical Society OBSERVATORIO DE ARECIBO NOCHE DE DE SERVACION

30 de junio | 6:00 p.m. - 9:00 p.m. en el Observatorio de Arecibo

RESEARCH EXPERIENCE FOR UNDERGRADUATES & TEACHERS



Everybody loves AO, even astronauts!

Scott Kelly

Paolo Nespoli









(UNISPACE+50)

Opportunities: AO – PR / Latin American scientific cooperation

UNOOSA/COPUOS: works to promote international cooperation in the peaceful use and exploration of space, and in the utilization of space science and technology for sustainable economic and social development.

Role of AO/PR Space Sciences in achieving the UN SDG. Space to the benefit of PR --> SDGs.





The Arecibo message

In **1974**, the SETI used the Arecibo Observatory to make the most powerful (~20TW) broadcast ever deliberately beamed into space, sending the message to the globular star cluster M13 (25,000 ly from us, in the edge of the Milky Way).

The NEW Arecibo message: 45 year later, what's new?

In **2019**, to celebrate the 45th anniversary of the first message, the Arecibo Observatory will send out an updated message, created by students! In the 2018 fall, we will release the **"New Arecibo message challenge".**

The 2018 #AOWeek will be used to promote this activity and engage the students.



Thank you!

Visitor Center: Wednesday - Sunday & Holidays

10:00 am - 3:00 pm

www.naic.edu +1 787-878-2612 EXT. 346 OR 312. info@naic.edu

Ale Pacini - apacini@naic.edu #AOWeek



THE ARECIBO OBSERVATORY

1992 Arecibo discovered the first ever exoplanet.

- In subsequent observations, an entire planetary system was found around the pulsar PSR 1257+12.

1992 Arecibo discovered ice at the North and South poles of Mercury.

- The ice persists in shadowed craters despite the high temperatures, 800°F, at the surface; this discovery was confirmed in 2014 by NASA's MESSENGER spacecraft.

1982 Arecibo discovered the first OH Megamaser in Arp 220, the nearest ultraluminous IR galaxy.

- Arp 220 is a merger undergoing a burst of star formation; the population inversion is produced by IR radiation from dust.

1982 Arecibo discovered the first millisecond pulsar, PSR 1937+21.

- This discovery of a second class of pulsar led to the suggestion that pulsars can spin-up by accreting mass from a companion.

1981 Arecibo produced the first radar maps of the surface of Venus.

- Optical images show only the top of the thick cloud layer.

1974 Arecibo discovered the first ever binary pulsar. Changes in periastron confirmed the predictions of General Relativity.

- The 1993 Nobel Prize in Physics was awarded to Hulse and Taylor for this discovery.

1968 Arecibo measured the 33-ms period of the Crab pulsar.

- Only sporadic radio pulses from the Crab nebula supernova remnant were know before Arecibo.

1967 Arecibo discovered that the rotation rate of Mercury is 59 days, not the previously estimated value of 88 days.

- The rotation is not tidally locked, but rather, the rate is an orbital resonance with 2 orbits for every 3 rotations.

ARECIBO OBSERVATORY

Arecibo houses the most powerful Five-hundred-meter Aperture Spherical Telescope (FAST) will not include planetary radar system in the world, essential for tracking potentially planetary radar and will not play a role in hazardous asteroids planetary defense Arecibo's diameter is 305 meters; it uses FAST is 500 m; it uses 300 m for a 225-meter diameter portion of the dish observations, making it 2x as sensitive as for most observations Arecibo for equivalent experiments Arecibo's incoherent scatter radar. FAST is designed as a purely airglow & LIDAR study the ionosphere, astronomical telescope and has no plans to study Earth's atmosphere space weather & climate change With a surface accuracy of about 2mm, FAST will operate from 1-1.8 GHz; the Arecibo operates from 1-10 GHz, limit is set by the precision with which allowing it to see emission from many the dish can be reshaped to approximate interstellar molecules a parabola Arecibo observes sources within 20 FAST can observe sources within 40 degrees of the local zenith, covering degrees of the local zenith, covering ~90% of the north & 25% of the south about 60% of the northern hemisphere Arecibo's tracking is faster & flexible, FAST will move slower since it needs to essential for observing sources distort its dish into a parabola Arecibo was recommissioned in 1997 FAST has just entered its commissioning following its last major upgrade and is phase and will not be fully operational for fully operational several years Arecibo has an established set of FAST will need to build a community of

FAST

users; time may not be available to the

FAST will have to establish research

international community

specialties



FACT

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FACT Arecibo has a proven track record of scientific discoveries

scientific observers; anyone can submit

proposals & compete for observing time