17th Australian Space Research Conference: plenary speakers

Dr Janaina Avila
Australian National University
"The pre-solar history of solar system matter"

Dr Janaína Ávila is a research fellow at the Australian National University (ANU). In 2011, she received her PhD in isotope cosmochemistry from the Research School of Earth Sciences (RSES, ANU). Since her PhD award, she has held postdoctoral fellowships at the Astronomy Department, University of São Paulo, where she continued research on nucleosynthetic signatures of heavy elements in AGB stars, and then at RSES-ANU, first as a Researcher in Business Postdoctoral Fellow and then as a research fellow. Dr Ávila research centres around the application of ion microprobes to the understanding of the isotopic nature of solar and presolar materials at the microscale. Dr Ávila is particularly interested in presolar grains recovered from primitive meteorites and the scientific implications of their isotopic signatures to the understanding of the origin of the elements and the chemical evolution of the galaxy and solar neighbourhood. Current interests include: (1) isotopic signatures of nucleosynthetic processes that occur inside stars, (2) environmental and biological evolutions on early Earth, and (3) factors influencing isotopic fractionation (mass-dependent and mass-independent fractionation) associated to sulfur and oxygen isotopes.

Plenary Abstract

The distribution of the chemical elements and their isotopes in our Solar System is a consequence of nuclear processes that have taken place in the Big Bang and subsequently in stars and in the interstellar medium (ISM). It depends on the entire history of stellar

birth and death, with associated return of newly synthesised elements to the ISM. For decades, researchers have looked to answer the following questions: How many sources with different nucleosynthetic histories contributed matter to the solar system, and what was the nature of these sources? What was the residence time of nuclides in the ISM before incorporation into the Sun's molecular cloud? Is the solar system abundance the result of a continuous history of star formation or of a peak epoch of stellar birth-rate activity? What is the history of p-, s-, and r-process enrichment in the solar neighbourhood? Astronomical observations of stellar objects have provided clues to some of these questions. However, the chemical information obtained from astronomical observations is not detailed and precise enough to constrain the timing and nature of nucleosynthetic sources and processes, as high-precision knowledge is required at an individual isotopic abundance level. A powerful source of information is provided by laboratory studies of presolar stardust grains. These grains are believed to be pristine stardust material that formed from the gas phase present in the atmospheres of late-type stars and in supernova ejecta. They were incorporated into the Sun's molecular cloud and survived the formation of the solar system with little processing. Today, presolar stardust grains can be found as constituents of primitive meteorites. In this talk, I will give an overview of the isotopic abundance patterns observed in presolar stardust grains as they encode precious information about the prehistory of the Solar System.

Professor Graziella Caprarelli
University of South Australia
"A world of ice and fire: Mars Unravelled"

Graziella Caprarelli (*PhD*, Earth Sciences, La Sapienza – Rome, Italy) is Associate Professor in Space Science at the University of South Australia in Adelaide, Australia, and Research Professor (Adj.) with the International Research School of Planetary Sciences in Italy.
After investigating volcanic and geothermal processes in Italy, Japan, NW USA, and ancient volcano-tectonic settings in eastern Australia, she turned her attention to Mars, and established collaborations with NASA and ESA mission science teams: currently she is member of the Co-Principal Investigator MARSIS Science Team based in Bologna, Italy, and collaborates with the SHAllow RADar sounder (SHARAD) Lead Investigator Team in Rome, Italy.
She has mentored students and Early Career Researchers, and supervised Honours and PhD projects in planetary and space science, which have resulted in the award of prestigious international prizes and scholarships.
Dr Caprarelli has been long standing member of the National Committee for Space and Radio Science (formerly the National Committee for Space Science) until 2016, and is one of the authors of the "Decadal Plan for Australian Space Science 2010-2019". She has chaired the NSW and SA Divisions of the Geological Society of Australia (GSA), and its Specialist Group in Planetary Geoscience.
In 2016 she was elected inaugural President of the Japan Society for the Promotion of Science - Alumni Association in Australia (JSPS-AAA). In the same year she established the South Australia Geotourism Subcommittee of GSA, of which she is inaugural Chair. She serves on national and international review and award panels, and is the Australian Journal of Earth Sciences Associate Editor for Planetary Geoscience.

Plenary Abstract

In this talk I will present some of the results my colleagues and I have obtained during our collaborative investigations of the Martian subsurface. Insights gained from interpretations of data from Mars Express (MEX) Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS), as well as characterizations of thermophysical properties of layered impact crater ejecta, provide a picture of the nature and distribution of subsurface ice and volatiles that is consistent with a complex sequence of geological and climatic events throughout the history of Mars. I will present the results of our work on Lucus Planum, the central region of the Medusae Fossae Formation (MFF), as well as some initial interpretations of MARSIS data collected over Lunae Planum, a vast expanse located between Valles Marineris to the south and Chryse Planitia to the north-east, emphasizing particularly the geologic significance of the data. I will also present and discuss evidence for sub-ice volcanism, providing additional testable hypotheses for future investigations. Our studies contribute to the increasing body of evidence pointing to magma-ice interaction as a significant and ubiquitous process in the geologic and climatic evolution of Mars.

Dr David Ciardi
NASA Exoplanet Science Institute, Caltech University
"NASA's Kepler Mission: Spawning a Revolution in Exoplanets and Beyond!"

David Ciardi research astronomer and the Chief Scientist at the NASA Exoplanet Science Institute located at IPAC / Caltech. He received a bachelor's degree in physics and astronomy from Boston University in 1991, and a Ph.D. in physics from the University of Wyoming in 1997.

Dr Ciardi has a huge range of scientific interests that includes exoplanets, star formation, interstellar dust, and molecular clouds. He has been a science team member of several exoplanet missions including CoRoT and Kepler and is the co-discoverer of more than 2000 exoplanets.

In 2016, Dr Ciardi was awarded the NASA Exceptional Scientific Achievement Medal for his work on Kepler and his contributions to the confirmation of Kepler's exoplanets which have led to the characterisation of planets ranging in size from Jupiters to Earths. The NASA Exceptional Scientific Achievement Medal is awarded to individuals for unusually significant scientific contributions toward achievement of aeronautical or space exploration goals.

Plenary Abstract

Launched in 2009 by NASA, the Kepler Mission has revolutionized the way in which view our own Solar System and the Earth. With more than 4500+ exoplanets discovered, Kepler turned our questions from "how do other solar systems look like our own" to "how does our Solar System fit into this complex and diverse Universe of planetary systems?" In addition, to exoplanets, Kepler has enabled a revolution in how we view and understand stars,

supernovae, and planets within our own Solar System. I will present an overview of the discoveries made by NASA's Kepler Mission over the past 9 years.

Tara Djokic
Australian Centre for Astrobiology,
University of NSW
"Hydrothermal systems, early life on Earth and implications for astrobiology"

Tara Djokic is a PhD candidate at the Australian Centre for Astrobiology of the University of New South Wales Australia. Her research interests include early life on Earth, astrobiology and science education. Recent projects include combining geological observations of early evidence of life in the c. 3.5 Ga Dresser Formation in Western Australia with virtual reality technology to produce a scientific educational tool in the form of a virtual field trip.

Her PhD research focuses on constraining the environmental setting in the Dresser Formation of the Pilbara. She has recently published in Nature Communications on Earths oldest evidence of land-based life and in Scientific American on her findings in the Pilbara and how they may be relevant in origin of life studies.

Plenary Abstract

Astrobiology seeks to answer questions regarding the origins and extent of life in the Universe. Geology provides a window in time that offers evidence needed to address these astrobiological questions.

The study of ~3.5 billion years old stromatolites from the Pilbara, Western Australia has shown that some of the earliest evidence of life on Earth was thriving in hot springs on land. This evidence provides a geological perspective that may be relevant in origin of

life studies as there are two prominent competing theories; deep-sea hydrothermal vents versus land-based hot springs.
The Pilbara findings also lend weight to the search for life on Mars, given that of the top three sites chosen to send the next Mars Rover (Mars2020), one of them has been interpreted as a land based hot spring setting (Columbia Hills). Further implications relate to investigations of the water-ice Moons of the Jupiter and Saturn systems.

Dr Duane Hamacher
Monash University
"Aboriginal Observations of Red-Giant Variable Stars"

Duane Hamacher is a Senior Research Fellow at the Monash University Indigenous Studies Centre and Adjunct Fellow in the Astrophysics Group at USQ. His research focuses on the astronomical knowledge of Indigenous people in Australia, the Pacific, and southeast Asia. His ARC funded DECRA research involves studying the astronomy of the Meriam Mir people of the Torres Strait.

He serves as Secretary of the *International Society of Archaeoastronomy and Astronomy in Culture*, Associate Editor of the *Journal of Astronomical History and Heritage*, and Chairs the IAU Working Group on Intangible Astronomical Heritage.

Plenary Abstract

Historians of astronomy recognise the observations of Sir John Hershel in 1840 as the first evidence that pulsating red-giant stars (like Betelgeuse) are variable in nature. This overturned the

accepted consensus that the stars are unchanging and invariable in nature - a position posed by Aristotle more than 2,000 years ago. But long before Herschel's observations in Cape Town, Aboriginal Australians had noted the variability of three red-giant stars and incorporated this into oral traditions. Two traditions, both from South Australia, describe the gradual brightening and dimming of these stars, along with descriptions of their relative periodicity. This talk will explore these traditions and show how these observations were missed by numerous ethnographers and researchers for over 150 years, highlighting the need for careful re-analysis of ethnographic research, as well as cross-disciplinary training in the social and natural sciences by ethnographers examining Indigenous Knowledge Systems. The talk will weave together astrophysics, anthropology, and traditional knowledge to show that Aboriginal people were extremely careful observers of the night sky, and that these ancient knowledge systems can work hand-in-hand with modern astrophysics for mutual benefit.

Julia Mitchell
CRC Spatial Information
"*The SBAS Testbed Demonstration Project*"

Julia Mitchell is currently the SBAS Testbed Program Manager at the CRC for Spatial Information. In this role, Julia coordinates a variety of projects over nine different industry sectors which aim to successfully demonstrate the benefits of the SBAS technologies.

Most recently, Julia has worked as a Spacecraft Systems Engineer on large communication satellite projects for the SES-16 and Jabiru-

1 spacecraft for SES and NewSat respectively. In prior roles, she has worked as a Structures and Graduate Engineer for Qantas for their Boeing 737 fleet and as an Aerospace Engineer for Aerospace Concepts (now the Shoal Group).

Julia has completed a Master of Science in Astronautics and Space Engineering from Cranfield University and combined Bachelor of Engineering (Aerospace) with first class honours and a Bachelor of Science (Physics) from the University of New South Wales.

Plenary Abstract

This SBAS Testbed is a satellite based positioning infrastructure that will available from June 2017 – January 2019. In simple terms the SBAS satellite provides a cost effective way to improve GPS signals from around 5 metres in accuracy to less than 1 metre. This trial is supported by a $12 million investment from the Australian Government as announced in January 2017 with a further $2 million from the New Zealand Government. CRCSI is coordinating and undertaking user testing of SBAS in Australia and New Zealand in conjunction with a benefit analysis of SBAS technology to Australia and New Zealand.

CRCSI partners, Geoscience Australia (GA) and Land Information New Zealand (LINZ) together with three global companies GMV, Inmarsat and Lockheed Martin will implement the SBAS testbed to evaluate three positioning signals for improved accuracy and integrity over Australia and New Zealand.

The positioning signals for evaluation are:

- The current L1 Legacy service similar to that available in the United States (WAAS), Europe (EGNOS), Japan (MSAS), India (GAGAN) and Russia (SDCM).
- A second-generation Dual Frequency Multi Constellation (DFMC) signal which will provide improvement over the legacy signal

in a number of areas. This signal has not been tested anywhere in the world.

- High-precision Precise Point Positioning (PPP) corrections with expected decimetre accuracies at user level.

Projects are currently running in Australia and NZ trialling the SBAS technology addressing applications in one or more of the following key sectors: aviation, road, rail, maritime, agriculture, resources, spatial, construction, utilities, and consumer. Julia will provide an update on the various projects, the various applications that have been identified where SBAS can be used and the benefits to the region.

Professor Dietmar Muller
University of Sydney
"*Seafloor tectonic fabric mapping from satellite altimetry: a key for modelling solid Earth evolution through deep time*"

Dietmar Müller received his undergraduate degree from the Univ. of Kiel, Germany, and his PhD in Earth Science from the Scripps Institution of Oceanography, La Jolla/California in 1993. After joining the University of Sydney in the same year he started building the EarthByte e-research group.

The EarthByters are pursuing open innovation, involving the collaborative development of open-source software as well as open-access global digital data sets and virtual globes. One of the fundamental aims of the EarthByte Group is geodata synthesis through space and time, assimilating the wealth of disparate geological and geophysical data into a four-dimensional Earth model, connecting solid Earth to surface processes. He held an Australian

Laureate Fellowship from 2009-2014, and is a Fellow of the American Geophysical Union and the Australian Academy of Sience. He currently directs the ARC Basin Genesis Hub as well as the Sydney Informatics Hub.

Plenary Abstract

Marine gravity anomalies derived from satellite radar altimetry now provide an unprecedented resolution for mapping small-scale seafloor and sub-seafloor tectonic fabric. Most of the new information comes from the CryoSat-2 satellite, which has routinely collected altimetry data over ice, land, and ocean since July 2010. To date it has completed more than 6 geodetic mapping cycles of the ocean surface. These data are augmented by a complete 14-month geodetic mapping of the ocean surface by Jason-1 from its lower inclination orbit of 66° that compliments the higher inclination orbit CryoSat-2 (88°). The most recent global marine gravity anomaly map based on a combination of geodetic mission data reveas the detailed fracture zone fabric of the ocean basinses, previously unmapped, now extinct oceanic microplates, and fault networks buried beneath thick sediments along continental margins. By combining satellite altimetry with marine magnetic anomalies and seafloor age dates from rock samples we are able to pinpoint the geometry and age of major plate reorganisations, which punctuate Earth's tectonic history. The combined data have been used to create a mathematical model, consisting of a large-set of Euler rotations, that describes how all major tectonic plates have moved relative to each other. We combine this model with data constraining the absolute motion of tectonic plates relative to a fixed reference system to construct a global plate motion model that is used as time-dependent boundary condition to model the evolution of Earth's entire plate-mantle system, to understand the feedbacks between "top-down" forcing of the system via plate recycling into

the mantle (subduction) and "bottom-up" forcing driven by the time-dependence of active mantle upwellings. In these spherical, thermochemical models of the Earth's mantle the equations for the conservation of mass, momentum, and energy are cast as a finite element problem and solved using the open-source CitcomS parallel code. The full spherical shell is composed of 12 parts, each subdivided into 128 3 128 3 64 elements, amounting to a total of 12.6 million elements. The mesh is refined radially to provide a vertical resolution of 15 km and 27 km near the top and bottom boundary layers, respectively. The lateral resolution is 50 km and 28 km at the surface and the core-mantle boundary, respectively. These models reveal how subduction drives the time-dependence of thermochemical mantle plumes, which rise from the core-mantle boundary to the surface and produce large volcanic eruptions and volcanic hotspot chains, occasionally leading to major extinctions

Professor Colin Waters
University of Newcastle
"Probing the ionosphere with HF signals: Space weather results from SuperDARN"

Colin Waters obtained his PhD in space physics in 1993 followed by post doctoral research at the University of Alberta, Edmonton, Canada. Returning to the University of Newcastle, he has taught undergraduate and postgraduate students in Physics, Engineering and Health science. Prof Waters has published ~100 research papers on ULF waves, energy exchange between the ionosphere and near Earth space via the large scale auroral (Birkeland) currents and space weather effects on technology such as gas pipeline corrosion and geomagnetic induced currents in electricity supply networks.

Research interests encompass experimental studies of ULF wave propagation in the magnetosphere and interaction with the ionosphere-ground system with applications to effects on Doppler HF radar operations and radio astronomy, computer simulations of space and fusion plasmas, experimental data analysis techniques and space weather phenomenon using global data sets such as SuperMAG, AMPERE and SuperDARN. He is co-chair of the IAGA Interdisciplinary Commission on Space Weather and has served on various national and international space science related committees including associate editor for Journal Geophysical Research - Space Physics. He has taught high school maths and science and served on the Higher School Certificate physics examination committee.

Plenary Abstract

The ionosphere is often represented as a boundary between the neutral atmosphere and space. The ionosphere electron density responds to space weather in different ways. Much progress has been made in understanding space weather dynamics in the ionosphere and in using this knowledge to infer energetic processes further out into space.

The Super Dual Auroral Radar Network (SuperDARN) is an international collaboration that spans the northern and southern auroral latitudes with high frequency (HF; 3-30MHz) coherent scatter radars, designed for ionospheric research. These radars detect backscatter from field aligned, decametre scale irregularities in the ionosphere and from the ground. The Doppler velocity, signal to noise ratio and spectral width parameters derived from the backscattered signals provide complimentary information on the response of the ionosphere to near-Earth space energetics. This talk will provide a guided tour of SuperDARN hardware and data, important advances and results and current research directions with an emphasis on space weather applications.