Project Title: Modelling fireballs on Mars and studying seismic effects

Lead Institution: Curtin University

Main Supervisor: Dr Katarina Miljkovic, Department of Applied Geology
Co-Supervisor: Prof Phil Bland, Department of Applied Geology
Associate Supervisor: Dr Gareth Collins, Imperial College London, UK

Project enquiries: katarina.miljkovic@curtin.edu.au

InSight

Project background

The space mission InSight (Interior exploration using Seismic Investigations, Geodesy and Heat Transport) will place a geophysical station on the surface of Mars in 2018. The seismic instrument SEIS (Seismic Experiment for Interior Structure) on-board InSight will quantify the seismic activity of the planet, which could be caused by a number of processes, from tectonic activity to meteorite impacts. This innovative mission will record meteoroid impacts on Mars through seismic responses of the atmosphere and the ground. Complex physics (much of it unsolved) lies behind the shock wave that is released during a hypervelocity impact. This will also be a way to study Martian atmosphere and interior.

The effect Martian atmosphere has on incoming meteoroids is unknown. Possible outcomes are grouped into three classes [1-2]: a) Meteoroids that survive the entire trajectory through the atmosphere and make a single impact on the ground; b) Meteoroids that burst and fragment in the atmosphere, and the fragments burn up in the atmosphere (airburst) [3]; c) Meteoroids that burst and fragment in the atmosphere, but the fragments do not completely burn up in the atmosphere; rather they make an impact in the ground in the form of a cluster of multiple craters [4]. Recent high-resolution mapping of small craters on Mars indicated that about 60% of them are clusters of craters [4-5]. This impact scenario is also the most complex.

Project aims and methods

This project involves numerical modelling of the three classes of meteoroid-impact outcomes. The investigation will focus on atmospheric ablation, drag and fragmentation as a function of meteoroid properties (projectile entry size, speed, angle, porosity, shape, density, and strength). The aim is to define the types of meteoroids that could cause a detectable seismic data signal and the specifications of the seismic signal after passing through the Martian atmosphere. This project will make use of the immense terrestrial observation dataset obtained by the Dessert Fireball Network (DFN, led by Prof Phil Bland) and will apply that knowledge on understanding of meteor physics and scale the impact outcomes to the Martian atmosphere. The expected outcomes will provide a synthesis of results and data into a

coherent understanding of the meteoroid bombardment on Mars, contributed from both the seismic and impact perspectives. This work will have important applications in data analyses of the forthcoming InSight mission to Mars.

Candidate

The ideal candidate would have a background in planetary geophysics, physics, geology, or astronomy, with an interest in Martian geophysics and space mission involvement.

Training

Training will depend on the specific interests and abilities of the PhD candidate, but could include: active involvement with the InSight mission science team, python programming, using the iSALE hydrocode, supercomputing usage, image processing, data manipulation and visualization.

References / Reading List

[1] Collins, G.S., H.J. Melosh, R.A. Marcus (2005) Earth Impact Effects Program: A Web-based computer program for calculating the regional environmental consequences of a meteoroid impact on Earth, Meteoritics & Planetary Science 40, Nr 6, 817–840.

[2] Miljković, K., E.K. Sansom, I.J. Daubar, F. Karakostas, P. Lognonné (2016) Fate of meteoroid impacts on Mars detectable by the InSight mission, 47th Lunar Planet. Sci. Conference, LPI Contribution No. 1768.

[3] Stevanović, J., N.A. Teanby, J., Wookey, N. Selby, I.J. Daubar, J. Vaubaillon, R. Garcia (2017) Bolide Airbursts as a Seismic Source for the 2018 Mars InSight Mission, Space Science Reviews 211, 525–545.

[4] Daubar, I.J., A.S. McEwen, S. Byrne, M.R. Kennedy, B. Ivanov (2013) The current martian cratering rate, Icarus 225 (2013) 506–516.

[5]Daubar, I.J., M.E. Banks, N.C. Schmerr, M.P. Golombek, W.K. Hartmann, E.C.S. Joseph, K. Miljković, O. Popova, and N. Teanby (2017) Crater clusters on Mars: Implications for atmospheric fragmentation, impactor properties, and seismic detectability, 48th Lunar Planet. Sci. Conference, LPI Contribution No. 2544.