PHYSICS&ASTRONOMY
THE UNIVERSITY OF TEXAS AT SAN ANTONIO

Dissertation Defense

Alexis Bouquet

Date: **: Tuesday, February 20th, 2018**

Time: **3:00 pm - 5:00 pm**

Location: **GSR 1.204**

Campus: **Main Campus**

Advisor: **Dr. Hunter Waite**

Abstract

Processes affecting the abundance of astrobiologically relevant compounds from icy bodies within the solar system

Several icy bodies of the solar system host, or are suspected to host, an ocean of liquid water beneath their icy crust. The most prominent two examples of these "ocean worlds" are Jupiter's moon Europa (target of the future Europa Clipper mission) and Saturn's moon Enceladus (object of abundant observations by the Cassini mission). The presence of liquid water raises the question of whether these bodies could host life as we know it. The first step in answering this question is to investigate their habitability: do these oceans offer suitable conditions for life to emerge and sustain itself? Habitability requires not only water, but a source of energy (chemical redox disequilibrium) and the availability of CHNOPS elements - Carbon, Hydrogen, Nitrogen, Oxygen, Phosphorus, Sulfur. Determining habitability can be done only through a comprehensive understanding of the chemical picture in the ocean.

We discuss several processes that can affect our understanding of compounds related to the habitability of a subglacial ocean, with a focus on Enceladus. This moon of Saturn offers an extraordinary opportunity to astrobiologists as its south pole is geologically active, with geysers that made ocean samples available to the Cassini spacecraft. However, analysis of these samples requires extensive interpretation to constrain the conditions in the ocean.

Clathrate formation can alter the abundance of volatile molecules in the ocean by trapping them in the ice shell. We use a statistical thermodynamic model to investigate this alteration and find that the abundance of methane relative to other volatiles in the plumes is higher than expected, indicating either a fast rate of production of methane in the ocean, or an ongoing destabilization of clathrate releasing their content into the ocean or the plumes, or a non-saturated ocean that is not favorable to clathrate formation.

The presence of molecular hydrogen (H2) in an ocean world is crucial for astrobiological considerations as it is a reactant in the metabolic process of methanogenesis, and only an ongoing production can ensure its presence in a small icy moon incapable of trapping a sizeable reservoir of this light molecule. We analyze the data of Cassini's Ion and Neutral Mass Spectrometer at Enceladus to disentangle the detection of H2 in the plumes from instrumental effects, and uncover several unresolved issues in our understanding of the instrument's response in this complex environment. We then investigate the role of endogenic radiolysis - the radiation chemistry of water induced by radioactive elements present in the rocky core - in the production of H2 in ocean worlds of the solar system. This process is a small but steady supplement to the hydrothermal production necessary to explain the amount of H2 seen at Enceladus.

Enceladus' plumes are generated by a system of cracks between the ocean and the surface, in which compounds in gas phase interact with the cold crack walls and the ice grains of the plumes. Various organics can adsorb onto the icy surfaces, with the stickiest compounds detectable mostly on the surface of ice grains rather than in gas phase. This bears consequences on what would be the most adequate type of observation for detecting these compounds, between remote observation, analysis of grains, or mass spectrometry focused on the gas phase. We model the adsorption of several light organics and find how oxygen-bearing compounds are more likely to be affected by adsorption, which has to be taken into account in our reading of Cassini data and of future observations of any ocean world.

Belinda Tucker • 210.458.8517 • Belinda.Tucker@utsa.edu

http://utsa.edu/physics/