Announcing the Final Examination of Mr. Akbar Whizin for the Degree of Doctor of Philosophy in Physics

Date: Monday, April 4, 2016
Time: 2:00 p.m.
Room: PSB 445 (4111 Libra Drive)
Dissertation title:
Dynamical Formation of Protoplanetesimals

Abstract:

Protoplanetesimals forming in the gaseous protoplanetary disk (PPD) have many physical barriers to overcome in their growth from millimeter to meter-sized and larger bodies. This stage of growth is widely accepted as one of the most uncertain steps in terrestrial planet formation due to the aggregates being weakly bound with non-existent self-gravity, and it is believed surface forces play a critical role in holding small loosely bound rubble-piles together. In order to determine the likely growth mechanisms of larger aggregates it is necessary to understand the macroscopic disk environment as well as the physics of the individual collisions between aggregates. To this end we analyze the orbital evolution and stability of an ensemble of particles in Saturn's F ring as an analogue to protoplanetesimals embedded in a PPD. We explore this concept in detail and find that the F ring does indeed lie in a stable zone, explaining the F ring's location, and a mechanism for producing stable formation zones for collisions in an evolving PPD. To understand the outcomes of protoplanetary collisions in the PPD we study how the mechanical, material, and collisional properties effect the dynamical accretion of cm-sized bodies. The collisional outcomes can be determined by a set of definable collision parameters, and experimental constraints on these parameters will improve astrophysical formation models of planetesimals. We have carried out a series of laboratory microgravity collision experiments of small aggregates made of protoplanetary material analogues to determine under what conditions collisional growth can occur. We measure important physical parameters like the coefficients of restitution, sticking and fragmentation thresholds, compressive strengths, and sticking probabilities for collision velocities of 1 - 200 cm/s. We then compare the results of our experiments with numerical results from a collisional N-body code, which we used to simulate rocky aggregates with cohesive inter-particle forces. We find that cm-sized aggregates are very weakly bound and require high internal cohesion to avoid fragmentation in agreement with simulations. The threshold for sticking is found to be just under 10 cm/s and the fragmentation threshold near 1 m/s. Quiescent regions in the mid-plane of the disk may cultivate abnormally low relative velocities permitting sticking to occur (~1 cm/s), however, without a well-defined path to formation from cm to meters in size it is difficult to determine whether collisional accretion as a mechanism can over-come the low energy thresholds for sticking and fragmentation paired with the ever increasing collision speeds. We discuss this research's implications to both the meter-barrier and planetesimal formation.

Outline of Studies:
Major: Physics, Planetary Sciences Track

Educational Career:
B.S. in Astrophysics, University of California Santa Cruz, 2008

Committee in Charge:
Dr. Joshua Colwell (Chair)
Dr. Yanga Fernandez
Dr. Richard Klemm
Dr. Mark Lewis (external committee member)
Dr. Brian Moore (external committee member)

Approved for distribution by Dr. Joshua Colwell, Committee Chair, on March 25, 2016.

The public is welcome to attend.