Executive Summary

Interest in astrophysics continues to grow in the general public, scientific community, and at Argonne. A committee of representatives from the Materials Science, Physics, and High Energy Physics divisions has discussed possible new programs in astrophysics, explicitly looking for a joint project that would be the basis for a lab-wide initiative. We have reviewed the current program in each division, discussed common areas of scientific interest, and surveyed possible experimental projects. These are examined in the committee report.

The most promising science theme that combines expertise and facilities at Argonne, common interests in each division, possibilities for growth, and national scientific priority, is supernova science and its connections to dark energy measurements. This initiative would address two of the eleven Grand Challenges in physics and astronomy identified by the National Academy of Science's "Turner Report": 1) the completely unknown nature of the dark energy which constitutes 70% of the universe, and 2) the origin of elements from iron to uranium, a subject with considerable effort and expertise currently at Argonne. These topics are intimately linked by experimental measurements and theoretical modeling of supernovae. Type 1a supernovae provided the initial discovery of dark energy in 1998, and are still the most mature technique in the study of its properties. Synthesis of half the nuclei heavier than iron is expected to occur in supernova explosions. Moreover, supernovae are interesting objects on their own and are the subject of additional science priorities at the funding agencies.

Multiple types of supernova will be used in dark energy studies, including Type 1a supernovae (detonations of white dwarfs) and gamma-ray bursts (a subset of core-collapse supernovae). On the experimental side this initiative would likely provide expertise in the techniques used to observe Type Ia supernovae and constrain dark energy with them. Expertise in gamma-ray bursts (GRBs) already exists in the HEP division with the recent hire of named-fellow Deirdre Horan, and the detection of GRBs is a priority of the VERITAS experiment. HEP is working on upgrades for VERITAS that will lower the gamma-ray energy threshold, thereby improving GRB detection.

Observations and models of supernovae will require tremendous refinement before they produce the desired constraints on dark energy. Theorists hired by this initiative, working with Jim Truran and Ken Nollett from PHY, and with scientists at the Flash Center, would work on the nuclear physics and astrophysics of supernovae. They would provide close coupling to theory for measurements made in all three divisions.

Existing facilities and expertise in PHY and MSD provide critical measurements for supernova models, and would also be greatly enhanced by new hires seeded by this initiative. Measurements of helium-burning rates are a top DOE nuclear astrophysics goal, and are vital for understanding supernovae. Measurements of pre-solar grains probe nucleosynthesis in supernovae, and the search for ^{244}Pu in deep-sea sediments will indicate whether *r*-process nucleosynthesis occurs in supernovae. Looking ahead, the committee sees a need for a longer period of study to determine what experimental opportunities are open to Argonne before a large investment in a single project is made.

Argonne has an opportunity to become a unique center for supernova studies, combining astrophysical measurements, theoretical studies, and accelerator and specialized-detector measurements to constrain supernova models and the evolution of dark energy.