Dr. Steven D. Howe
Hbar Technologies, LLC
Antimatter Driven Sail for Deep Space

Recent discoveries in observational astronomy made during the past decade have revolutionized our understanding of the universe, our galaxy, and our solar system's local environment. The existence of a ring of asteroids around our solar system, of large unseen clouds of dust in the interstellar neighborhood, and of the potential presence of "dark matter" throughout the universe have all drastically altered our view of cosmology. However, direct observation of some of these major concepts has yet to be accomplished. The number + question [ ] recently posed by the National Research Council Committee on Physics is "What is dark matter?" To answer this question and many others in cosmology may require send probes into deep space.

The ultimate goal of this project is to identify and investigate an exploration architecture that would allow a lightweight instrument package to be sent to another stellar system. Due to the difficulty inherent in an interstellar mission, however, we have examined the architecture in Phase I under the auspices of a less demanding mission (i.e., sending a probe to 250 AU, the Kuiper Belt, in 10 years. Such a mission is still beyond the capability of NASA or any other agency using currently available technology.

We have evaluated the concept of the Antimatter Driven Sail (ADS). In Phase I, we examined three major areas: Mission Architecture, Subsystem Technologies, and a Technology Roadmap. The Mission Architecture effort has focused on developing an integrated systems model to evaluate the performance of the entire spacecraft for a mission. The Subsystem Technologies investigation examined 1) the fundamental reactions between the antiprotons and the sail material and the subsequent momentum transfer, 2) a concept for storing anti-hydrogen at high densities, and 3) an entirely new concept for electrical power production. The new electrical power concept may have applicability to nearer term space missions as a power supply if the availability of anti-protons becomes common. In developing the Technology Roadmap, we examined the potential 1) for using recent developments in anti-proton storage and hydrogen formation to create a path to ultra-high density anti-hydrogen storage, and 2) for increasing production of anti-protons by modifying the existing _er_ lab facility.

The Phase I project was very successful. Our system analysis indicates that a 10mg instrument payload could be sent to 250 AU in 10 years using 30 milligrams of anti-hydrogen. This amount of antimatter is clearly within the product _on potential of the US within the next 40 years using currently accepted accelerator technologies. In addition, preliminary calculations also indicate that this architecture could enable a similar probe to be sent to the next star, Alpha Centaur, in 40 years using grams of antimatter. Previous investigations by JPL had concluded that _lograms of antimatter would be needed for an interstellar mission.

The system studies contained a variety of assumptions with regard to technology subsystems. First of all, the actual momentum transferred to the sail from antimatter fission is in question and is a critical factor. The second issue is the feasibility of storing antimatter micron pellets in solid state circuits. Initially, the development of a high specific mass electrical power supply based on Antimatter Mission Conversion is proposed based on currently available technologies. The combination of all these factors dictates the performance of the spacecraft.

In Phase I we determined the steady-state conditions of the spacecraft (e.g., we determined the maximum temperatures of the sail and the power radiator). More specifically, we performed no time-dependent estimates with regard to heating, radiation levels, or thermal cycling of spacecraft components. In addition, we did not incorporate any orbital mechanic's "tricks" such as gravity assists or perhaps is pumping to reduce the delta V demand on the propulsion system. Phase I determined that the architecture could achieve the mission goals without exceeding physical constraints on materials. To more accurately assess the performance of his architecture, time dependent aspects during the mission must be addressed.

In Phase II, we will continue the definition of this revolutionary architecture. Not only will we complete the design of the Kuiper Belt mission, but we intend to design a spacecraft to travel to the nearest star. We intend to perform the following: 1) complete a detailed analysis of the operations of the spacecraft during the entire mission, i.e., all time dependent processes of heat transfer and radiation deposition; 2) design two missions -- a) the Kuiper Belt mission and b) an interstellar mission to Alpha Centaur; 3) optimize the mission profiles with regard to utilizing the benefits of orbital mechanics; and 4) perform a proof of concept experiment using antiprotons irradiation of a uranium foil to measure the actual momentum transferred to the foil.

The final result of the Phase I study is that the concept of sending an instrument package into really deep space to understand the major questions in astrophysics and cosmology may indeed be within our grasp. This project has garnered the imagination of the public as evidenced by the numerous press interviews [2,3] made by Hbar Technologies personnel after the NIAC Fellows Meeting in October, 2002. Major aspects of the architecture remain to be investigated, but the first cut assessment of the mission profile, the subsystem technologies, and the technology development path have all been identified. The anti-matter driven sail may in fact allow humanity to consider sending probes to the stars.