PROPOSED CITATION

NASA EXCEPTIONAL SCIENTIFIC ACHIEVEMENT AWARD - 1997

Dr. Michael A. Minovitch

JET PROPULSION LABORATORY

For the origination of the concept and analytical solution procedures for achieving space travel throughout the Solar System by replacing direct-transfer interplanetary trajectories to target planets with indirect trajectories passing one or more intermediate planets to reach high-energy post-encounter trajectories without rocket propulsion via gravitational interactions from the intermediate planets that would be difficult or impossible to reach directly with rocket propulsion. This was the key innovative breakthrough that made it possible to circumvent the high-energy barriers of direct-transfer trajectories to target planets thereby enabling the exploration of the entire Solar System with instrumented spacecraft.

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For inventing and developing the concept of gravity propelled interplanetary space travel. This revolutionary concept, formulated in 1961 by Dr. Minovitch at the California Institute of Technology's Jet Propulsion Laboratory, enables space vehicles launched on relatively low-energy initial transfer trajectories, to travel throughout the entire Solar System by substituting conventional rocket propulsion with gravitational forces generated by passing planets. These gravity propelled trajectories can be expressed by sequences of the form $P_0 - P_1 - P_2 - ... - P_n$ where P_0 denotes the initial point or launch planet, and P_n denotes the terminal point or arrival planet. He viewed each intermediate planet P_i as a moving gravitational field which interacts with the vehicle's mass to provide the necessary propulsive thrust to reach P_{i+1}. Once the vehicle is launched onto its first leg to an easy to reach nearby planet, all subsequent interplanetary trajectory changes are accomplished essentially free-of-charge by a series of controlled gravitational interactions. Control is accomplished by selecting various planetary approach trajectories. Since these gravitational propulsive forces increase automatically with vehicle mass as prescribed by the Newtonian equivalence principle, it does not matter how massive the vehicle is once it is launched. Hence, in this concept of vehicle propulsion there is no upper limit on the amount of free energy available to carry out interplanetary propulsive maneuvers. Thus, Dr. Minovitch discovered a method for achieving interplanetary space travel throughout the Solar System which derives its propulsive energy from the essentially inexhaustible and infinite orbital energies of the various planets.

Another noted achievement of Dr. Minovitch's work was his analytical formulation of the first general numerical solution of the famous N-Body Problem of celestial mechanics for precisely determining the required flight paths around the propulsion planets. The concept of gravity propelled interplanetary space travel required a solution to the N-Body Problem for interplanetary trajectories in order to investigate the concept numerically and to use it in an actual mission. In 1961 this problem was considered to be one of the most difficult unsolved problems in celestial mechanics.

Following his theoretical work, Dr. Minovitch initiated a large scale numerical investigation of the concept in 1962. These computations proved that the concept could be used to explore the outer Solar System, regions close to the sun, and regions far above and below the ecliptic plane with

relatively small launch vehicles and conventional rocket propulsion which was previously believed to be impossible without exotic propulsion systems such as nuclear and electric systems. Since these systems proved to be beyond technical feasibility, Dr. Minovitch's work represented the key innovation that made it possible to explore the entire Solar System with instrumented spacecraft. The missions that were made possible by this innovation were: Earth-Venus-Mercury (Mariner 10); Earth-Jupiter-Interstellar (Pioneer 10); Earth-Jupiter-Saturn-Interstellar (Pioneer 11); Earth-Jupiter-Saturn-Interstellar (Voyager 1); Earth-Jupiter-Saturn-Uranus-Neptune-Interstellar (Voyager 2); Earth-Jupiter-Out Of Ecliptic (Ulysses); and Earth-Venus-Earth-Earth-Jupiter (Galileo). The combined scientific information obtained from these missions enabled most of the physical structure of the Solar System and near interstellar space to be determined which would have been impossible without Dr. Minovitch's innovation.