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Conceptual study of manned space transportation vehicle using laser thruster in combination with the H-II rocket

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ABSTRACT

This paper describes the conceptual study of a Manned Space Transportation Vehicle (MSTV) using a laser thruster in combination with the H-II Rocket. By combining the use of a laser thruster and H-II Rocket, space trip to the International Space Station (ISS) or a round trip mission around the moon can be performed. Once MSTV with one crew achieves a circular orbit at an altitude of 200 km around the earth (parking orbit) by use of H-II Rocket, MSTV will then put into a circular orbit into an altitude of 400 km (ISS orbit) from 200 km circular orbit by use of the laser thruster. H-II Rocket has the following launch capability with payloads for LEO (300 km): 10 t (H-II A Rocket), 16.5 t (H-II B Rocket). Laser thruster using water propellant, power source for the laser, orbital transfer calculations (to ISS or the Moon) and other practical aspects are examined.

1. Introduction

Nowadays, the space trip business in the private sector aiming at weightless experience is becoming a reality in Europe and the United States. For example, "Space Ship One" or "Space Ship Two" systems are well known at present to the general public.

Now, there are three kinds of space trips such as sub-orbital trip, orbital trip and round trip around the moon that are being prepared for a space trip, which can be purchased through a travel company or an agency. Sub-orbital trips are aimed at a short-duration weightless experience. That is, the carrier-launch aircraft would suspend beneath a carry space vehicle to an altitude of 15 km and then release it. Shortly after release, the space vehicle would fire its hybrid rocket engine and continue on a ballistic ascent to 110 km altitude. The orbital trip would stay at the International Space Station (ISS) or at a space hotel, carrying out earth observation and enjoying the weightless experience. The Soyuz spacecraft has stayed at the ISS from the past to the present. Round trip around the moon is planned where the Soyuz spacecraft is docked with a moon rocket that is assembled in the ISS. After a stay at the ISS or a space hotel, they will go to the moon with the rocket. There are currently seven companies working on space vehicle development for sub orbital trip, six companies are working on space vehicle developments for orbital trips and four companies for round trips around the moon. Although all space vehicles under development are based on a chemical rocket engine system, each company adopts its original launch system. We propose the concept of the Manned Space Transportation Vehicle (MSTV) using a laser thruster in combination with the H-II Rocket for an orbital trip and round trip around the moon. By combined use of laser thruster and H-II Rocket, space transfer can be performed by the following two steps: (1) MSTV with one crew put into circular orbit in an altitude of 200 km around the earth (parking orbit) using H-II Rocket, (2) MSTV is put into

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circular orbit in an altitude of 400 km (ISS orbit) from 200 km circular orbit by using a laser thruster. The H-II Rocket has the following launch capability of payloads for LEO (Low Earth Orbit) at 300km: 10 t (H-II A Rocket), 16.5 t (H-II B Rocket).

Putting a heavy load like an MSTV (5–14 t payload) into the orbit of the ISS or a space hotel directly is technically very difficulty. First, it is required to put an MSTV into the low earth orbit of an altitude of 200 km. Afterwards, the orbital transfer between the 200 km circular orbit to the 400 km circular orbit is performed and finally MSTV arrives at the ISS or a space hotel at an altitude of 400 km. MSTV uses a laser thruster in which speed control is possible to achieve orbital transfer with high precision accuracy.

The external view of the MSTV with a propulsion engine replaced by the laser thruster has a wing type body like the Space Shuttle. Fig. 1 shows an example of a laser thruster. Using steam laser heating, water is preheated and ejected as a supersonic flow that ensures the thermal decoupling of the nozzle wall and the region that is super heated by the laser. MSTV is propelled by the laser propulsion engine, i.e., laser thruster using water as a propellant. The feature of laser propulsion is that both thrust and specific impulse (I_{SP}) can be arbitrarily controlled with laser power density (W/cm^2) [1–9]. Since the exhaust velocity and fluid conditions of a propellant can be controlled by means of combinations using laser parameters such as intensity, wavelength and propellants, the selection between high thrust system and high specific impulse (I_{SP}) system can be easily implemented. The high-precision velocity of MSTV can be precisely controlled by the laser power density. Additionally, since MSTV does not use liquid hydrogen or liquid oxygen but the water as propellant, it is a promising highly safe technology.

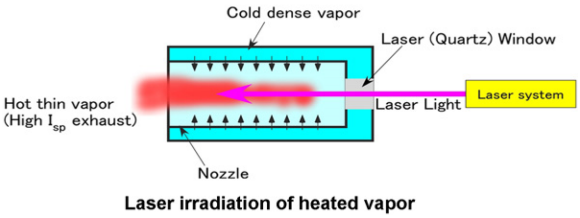

Fig. 1. An example of laser thruster (Propellant: vapour).

In Japan, since there is already an H-II Rocket, which launches a satellite and HTV (H-II Transfer Vehicle), MSTV is launched and put into LEO at 200 km with H-II Rocket. Orbital transfer is performed to arrive at the ISS or a space hotel of LEO 400 km by the laser thruster using water propellant. Basically, rocket driver trajectory for the MSTV is almost the same as that of Japanese HTV (H-II Transfer Vehicle) [10–12].

Details of an MSTV are given below from a viewpoint on the laser thruster, laser power and system design.

2. Manned space mission scenario

The gross weight of the MSTV that is propelled by the laser thruster using water as a propellant assumes temporarily 5t (bodies 3t+water 2t). The mission target is the International Space Station (ISS) with an altitude of about 400 km or a space hotel built in near ISS. MSTV is launched with the H-II Rocket and is directly thrown into a circular orbit at an altitude of 200 km around the earth (parking orbit). Once MSTV is thrown into a circular orbit with an altitude of 200 km, docking to ISS in an altitude of 400 km that will be safely attained by highly precise crew

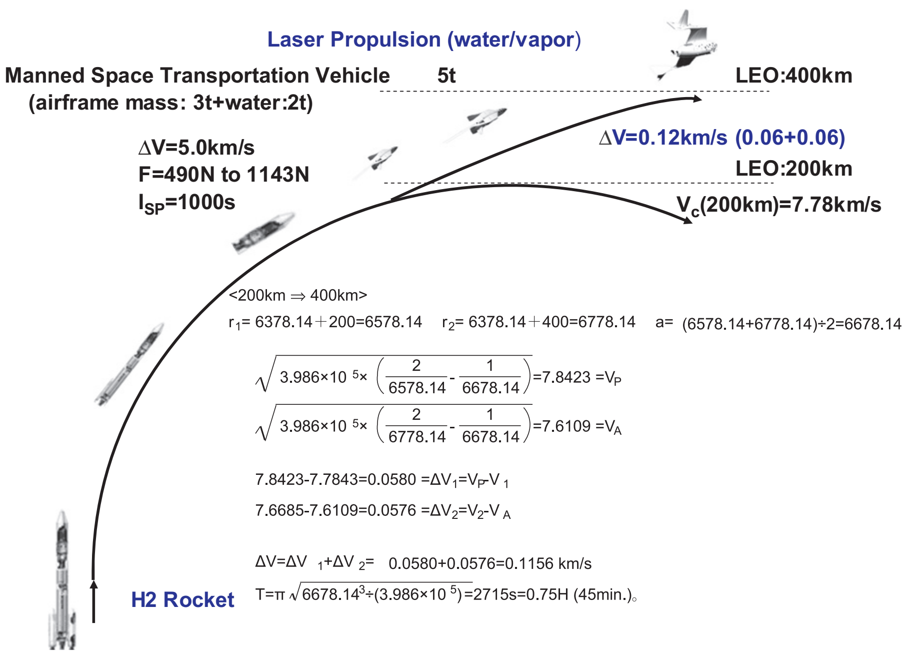

Fig. 2. Launch to LEO (200 km to ISS: 400 km).