Suborbital Demonstrations of Starshades

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Abstract

Starshades are specially designed external occulters that block unwanted light from stars to provide the high contrast (10^{-10}) needed for the imaging and characterizing of Earth-like planets around other stars. To prepare for a future large-scale starshade mission, we are conducting a suite of starshade demonstrations through astronomical observations. The use of suborbital vehicles will allow us to achieve large separations and precise positioning between starshade and telescope.

Dirigible

Our initial suborbital platform was a Zeppelin dirigible (housed at NASA Ames) in which we developed a visual positioning system, ***Janus***, that allows for precision formation flying between two vehicles. Such a device will be necessary for a future starshade mission working in tandem with a passive JWST. We successfully flew our system on the dirigible in October 2012, before the company that operated the dirigible went out of business. We are now redesigning the program to use on other suborbital platforms.

Suborbital Reusable Launch Vehicle

Future development of the Janus system will be done with the help of Suborbital Reusable Launch Vehicles (sRLV) such as Masten Space Systems' ***Xaero*** and ***Xombie***. These vehicles' stable flight at high altitudes provide the large separations needed between a ground telescope and Janus. Porting the visual information obtained by Janus to the sRLV's Guidance and Navigation systems will provide extraordinarily high precision position information needed for formation flying. After achieving formation flying, we can fly two sRLVs in tandem - one equipped with a 0.5 m telescope, the other with a starshade - and start doing astronomy. The tight constraints of our experiment will push the sRLV's capabilities and will drive its development as a science platform. Short flight turnaround times, inexpensive flight costs, and the ability to re-fly payloads make sRLVs ideal platforms for suborbital science.

Global Hawk UAV

There is very exciting science to be done with starshades and the help of NASA's ***Global Hawk*** UAV. A 0.5 m near-UV telescope on a Global Hawk flying in tandem with a 2 m starshade on a high-altitude balloon will allow us to achieve 300 km telescope-starshade separation in the stratosphere. Yielding an inner working angle of 0.7 arcseconds, we will get the first direct images of the habitable zone (down to 1 AU) of our nearest neighbor, Alpha Centauri. Initial exposures will easily quantify the exozodiacal dust in nearby systems, a value critical for future exo-Earth imaging missions. Longer exposures will allow us to image and characterize Earth-like planets within the habitable zone! The specially made telescope pod on the Global Hawk's wing will open the door to using Global Hawks for suborbital astronomy.

Conclusions

We are continuing work using suborbital vehicles as a means to provide the separation and flight stability needed to demonstrate and develop starshade technology. We will map the exozodiacal light and possibly discover Earth-like planets around nearby stars. Scientific results from such demonstrations will help to ensure the selection of starshades for the next exoplanet imaging mission. Work from this program will also help to make these suborbital vehicles, namely the Xaero and Global Hawk, available as science platforms for the astronomy community.

Figure 1: **(left)** Janus system on Dirigible **(right)** Masten Space System's Xaero (masten-space.org)