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Strategies for Rapid Implementation of Interstellar Missions: Precursors and Beyond (4)

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# THE STARSHOT COMMUNICATION DOWNLINK

**Abstract**

Breakthrough Starshot is an initiative to propel a sailcraft to $\alpha$ Centauri within the next generation. The sailcraft looks for signs of life by imaging planets and gathering other scientific data. After the flyby, the communication downlink returns the data to an Earth-based receiver. The volume of data returned greatly affects the mission's attractiveness, so it is addressed here before other sailcraft subsystems.

Existing analyses show that optical wavelength data return is feasible from probes at $\alpha$ Centauri distances. The Starshot sailcraft is 4.1 meters in diameter and assumed to use its whole area to transmit 70 Watts at 1.02 microns (1.25 microns after redshifting from 0.2 c to the receiver frame). The present work proceeds from the insight that, because of its proper motion, $\alpha$ Centauri shares the receiver's field of view with the sailcraft for only hours to days during the sailcraft's flyby, when the sailcraft is oriented to gather sensor data. For the subsequent downlink, which ideally lasts months to years, the dominant source of background noise is starlight reflected from $\alpha$ Centauri's smooth dust disk.

A 30-meter telescope is estimated to gather 141 photons/second from the sailcraft after accounting for relativistic effects (-3.5 dB), atmospheric transmittance (-1.0 dB), and link margin (-3.0 dB). For this photon-starved Poisson channel, and assuming 0.1 nm equivalent noise bandwidth and 90% detector quantum efficiency, 1024-ary PPM modulation should operate between 100 bit/s (hard-decision) and 1 kbit/s (theoretical maximum) for a $10^{-3}$ raw bit error rate. Of order 1-10 gigabits/year are returned.