Zodiac II is a proposed telescope-coronagraph system, operating at visible wavelengths, mounted on a balloon-borne gondola in the stratosphere. The science objective is to image debris disks around nearby stars. Debris disks, usually found in the outer reaches of a planetary system, are significant for exoplanet science because (a) they tell us that planet formation did actually get started around a star, (b) they are a contributing source of potentially obscuring dust in the inner part of the disk where we will someday start searching for terrestrial planets, and (c) for a disk with an inner edge, this feature is a signpost for a shepherding planet and thus a sign that planet formation did indeed proceed to completion around that star.

The proposed telescope has a 1.1-m diameter, clear-aperture primary mirror, designed to operate in the cold stratospheric environment. The coronagraph is designed to suppress starlight, including its diffracted and scattered components, and allow a faint surrounding debris disk to be imaged. We will control the speckle background to be about 7 orders of magnitude fainter than the star, with detection sensitivity about one more order of magnitude fainter, in order to comfortably image the expected brightness of typical debris disks. Zodiac II will be designed to make scientifically useful measurements on a conventional overnight balloon flight, but would also be fully compatible with future Long Duration Balloon flights. Zodiac II has a technical objective of advancing the technology levels of future mission components from the lab to near-space flight status. These components include deformable mirrors, wavefront sensors, coronagraph masks, lightweight mirrors, precision pointing, and speckle rejection by wavefront control.

Zodiac II will have a 1.1-m clear-aperture, off-axis primary mirror made of light-weight, thermally-stable SiC, controlled to room temperature. Its high-performance coronagraph will contain fine guidance controls which, combined with new gondola pointing systems, will provide the PSF stability required to reach a speckle contrast level of $10^{-7}$.

The Coronagraph

A coronagraph design has been developed based on results from JPL’s High-Contrast Imaging Testbed (HCIT) and from the ACCESS mission concept study.

To advance imaging technology in preparation for direct imaging of Earth-like extrasolar planets

Debris disks and planets are intimately related:
- All three of the stars with imaged planetary systems also host prominent debris disks.
- The planets in those systems directly sculpt the disk structure through gap clearing and ring shepherding.
- The planet orbiting Fomalhaut was successfully predicted based on its Spitzer IR image. The expected disk eccentricity was confirmed by HST.
- Herschel is marginally resolving many debris disks at far-IR wavelengths, many with similarly asymmetric profiles.
- Visible-light observations have ~100x greater contrast than ground-based instruments, and ~100x fainter than Spitzer.

Images of debris disk structure – gaps, rings, offsets, warps, and clumps – provide evidence for the locations of faint planets embedded within brighter disks.
- Debris disks are likely not at equal distance from the star. They are typically offset, warped, and offset in the inner part of the disk where we will someday start searching for terrestrial planets, and (c) for a disk with an inner edge, this feature is a signpost for a shepherding planet and thus a sign that planet formation did indeed proceed to completion around that star.

Detection Limits

The post-processing contrast floor for Zodiac II is shown as a function of angular separation (solid line). The 99 potential targets for Zodiac II derived from Spitzer data, are shown as solid circles. Some other targets for past and future ground and space instruments are also shown. The detected giant planets orbiting HR 8799 are shown as red stars.