A Search for Substellar Companions of the Debris Disk Star ε Eridani with the Spitzer Space Telescope


ε Eridani (HD 223849, d = 32 pc) is one of the “Fabulous Four” debris disk stars discovered by IRAS (together with Vega, Fomalhaut, and ρ Pictoris). Observations with the Multiband Imaging Photometer (MIPS) and the InfraRed Spectrometer (IRS) of the Spitzer Space Telescope have confirmed the presence of the disk, and provided evidence for asymmetries in the disk structure that may be induced by the gravitational perturbation of substellar companions. With an age of 730 Myr (Song et al. 2000), ε Eridani represents a particularly interesting object for studying the evolution of debris disks and their associated exoplanetary companions.

We present here a search for substellar companions of ε Eridani which is being carried on with the Infrared Array Camera (IRAC) of Spitzer. The optical quality and high dynamic range of the camera is specially tuned to detect faint companions around bright stars, and its four bandpasses at 3.6, 4.5, 5.8 and 8.0 μm are ideal for the search of substellar objects by detecting their molecular spectral features.

We discuss the special techniques we have developed to reduce the effects of the bright central star which is the main limiting factor in allowing the detection of faint companions, and the sensitivity limits that our techniques can reach.

An IRAC image of a star at 3.6 μm. This is a false-color image, with blue representing objects that are cooler and red representing objects that are warmer. The image shows a central star with a bright, disk-like structure surrounding it, indicating the presence of a debris disk.

A PSF-subtracted image of ε Eridani at 3.6 μm. This image has been processed to remove the effects of the bright central star, allowing for the detection of faint companions in the vicinity of the star.

Contour levels indicate 10, 12, 14, 16 and 18 magnitudes detection limits. The brighter contours represent areas with higher sensitivity, while the fainter contours indicate regions with lower sensitivity.

The Spitzer Infrared Array Camera (IRAC) is a 4-band, mid-infrared camera that is part of the Spitzer Space Telescope. It is used to study the properties of young stars, planets, and galaxies.

**Source detection**

The two panels on top show the 3.6 μm IRAC images of ε Eridani (left) and β Pictoris (right). The images are subtraction images, which are used to enhance the visibility of faint companions by subtracting the brightness of the central star.

**Sensitivity maps**

The ability of these techniques to remove the central star's light and allow the detection of faint companions is shown in the maps of the right. The grey-scale images show the intrinsic noise in the PSF and are color-coded to indicate the sensitivity of the instrument. The sensitivity is measured by the contrast in the images, which shows how well the instrument can detect faint companions.

**Work in progress**

We are currently analyzing the photometry of the more than 400 sources detected in the 3.6 μm PSF-subtracted images. We will present the results of our search in a forthcoming paper which is currently in progress.