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# Direct Imaging of Circumstellar Disks in the Orion Nebula

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**Abstract.** We present observations of the Orion Nebula made with the Hubble Space Telescope in which a number of stars are seen surrounded by dark silhouettes seen projected against the bright background H II region. We find a variety of morphologies, all consistent with thin circumstellar disks spanning a range of diameters (50 to 1000 AU) and inclination angles (0 to >80 degrees). The silhouette intensity profiles cannot be fit by standard disk models in which the surface density follows a radial power law with an exponent in the range $-0.75$ to $-1.5$. Rather, the data are best fit by opaque inner disks with exponential edges, and we discuss possible physical origins of this apparent truncation. Masses in the range $6\times10^{26}$–$4\times10^{30}$ g (*i.e.*, up to $0.002\,M_\odot$) are determined for the disks by assuming that the faint light measured from them is background light transmitted through the disk. However, these are strict lower limits on the true disk masses, as most of this light can be accounted for by PSF blurring and scattering in the HST optical train; the present observations are in fact consistent with completely opaque disks. Central stars are seen directly in five of the silhouettes, while the presence of a star is inferred in the sixth, where small reflection nebulae are seen above and below the plane of the near edge-on disk. Optical and near-infrared stellar photometry is consistent with young ($\sim$1 Myr) low-mass ($0.3$–$1.5\,M_\odot$) stars, with several showing evidence for excess near-infrared emission from the disk inner edge. These direct imaging observations are discussed in the wider context of circumstellar disks in the Orion Nebula and Trapezium Cluster, additionally revealed as compact ionized nebulae (so-called "proplyds") in the vicinity of the central OB stars, and via infrared (>2$\mu$m) excesses in stellar photometry. Overall, disks are found to be common in the cluster (>50% of all stars), implying that they can survive the rigours of life near massive stars.

## 1. Summary

The material presented on circumstellar disks in the Orion Nebula at the meeting is well covered in a number of published and in-press papers. It is therefore not described at length here, beyond a brief summary in the abstract, a list of pertinent references, and one figure showing the silhouette disks.

The key paper is McCaughrean & O'Dell (1996), which describes the HST observations of the silhouette disks and their analysis. The HST observations

of the ionized proplyds are described in papers by O'Dell, Wen, & Hu (1993), Stauffer *et al.* (1994), O'Dell & Wen (1994), O'Dell & Wong (1996), and Bally, Devine, & Sutherland (1995). Infrared observations of the ionized proplyds and silhouette disks are described in McCaughrean & Stauffer (1994), McCaughrean *et al.* (1996), and Hayward & McCaughrean (1997).

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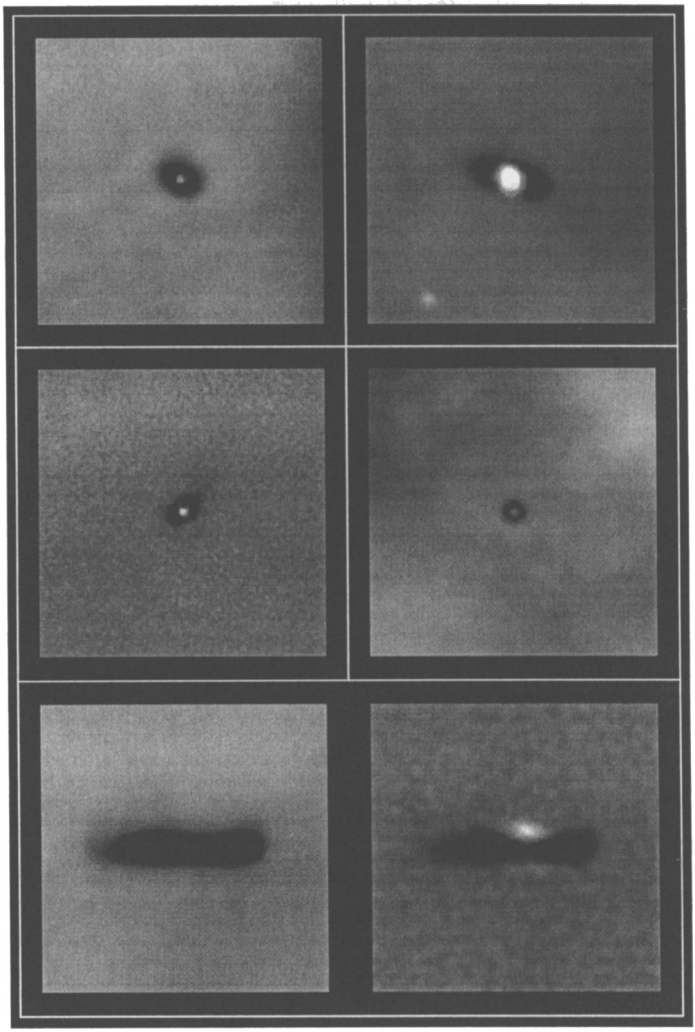

Figure 1. HST images of silhouette disks in the Orion Nebula. The top four panels show emission-line images of (clockwise from upper left) Orion 183-405, Orion 218-354, Orion 167-231, and Orion 121-1925. In each of these images, the central star is seen surrounded by a dark silhouette projected against the background H II region emission of the Orion Nebula. Three of the silhouettes are elliptical, leading to the conclusion that these are circumstellar disks. The bottom two panels show emission-line (left) and continuum (right) images of Orion 114-426. No star is seen in either image, but the continuum image reveals faint nebulosities above and below the plane of the silhouette, indicating that this is a near edge-on disk with small polar reflection nebulae. All the images are 1800×1800 AU in size.

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