Galaxy Kinematics with Integral Field Spectroscopy

David R. Andersen

Department of Astronomy and Astrophysics, Penn State University, University Park, PA 16802

Matthew A. Bershady

Department of Astronomy, University of Wisconsin – Madison, Madison, WI 53706

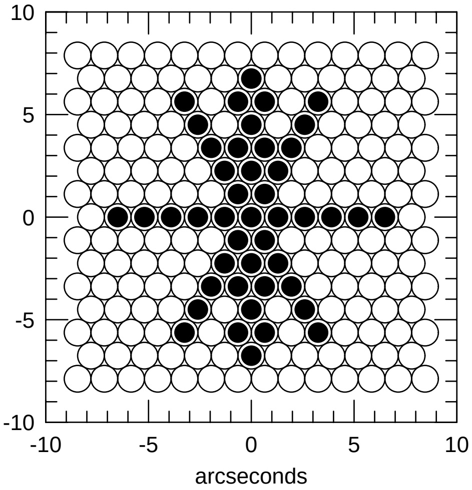
1. Science Mission

The integral field unit (IFU), nicknamed "Spider" (Figure 1), is a fiber optic array under construction for the 9m Hobby-Eberly Telescope's (HET) Medium Resolution Spectrograph (MRS). This contribution updates previous reports (Bershady et al. 1998), and represents the final design for this instrument. Spider is optimized for integral field spectroscopy for kinematic studies of nearby and moderately distant galaxies, but will have more general application to moderate spectral resolution studies of extended sources at low surface-brightness (Bershady 1997). The IFU will be capable of delivering simultaneous rotation curves and disk velocity dispersions over a range of look-back times.

Rotation curve and disk velocity dispersion measurements from integral field spectroscopy allow for separate estimates of the disk and total masses and allow us to probe the axisymmetry of spiral disks. A critical limitation has been the inefficiency of traditional long–slit measurements made on 4m class telescopes. Integral field spectroscopy using high–throughput echelle spectrographs promise to open a new window on the mass and mass distributions of galaxies over a range of look–back times.

2. Performance

The IFU covers an area of 15 by 15 arcseconds using 1 arcsecond (200 μm) fibers to densely sample slits at 4 position angles at resolutions from 5500 to 14500. Our 200 μm array will be installed during the commissioning phase of the MRS (mid-1999). This fiber-fed echelle spectrograph has a resolution of 10,900 for a 1 arcsec aperture, and initial spectral coverage from 0.5-0.95 μm in a red beam. The IFU coupled to the MRS spectrograph is expected to reach a limiting surface-brightness in V of 22 at S/N = 10 per spectral resolution element per fiber at R = 10,900 in one hour (Figure 2); this assumes a peak throughput of 15% for the HET plus MRS system (Ramsey 1995). The large telescope aperture and fiber size of Spider yields large étendue (50 m^2 arcsec^2). We are unaware of other fiber arrays planned or in existence which have comparable étendue and spectral resolution. Consequently, this IFU fills a niche for moderate resolution spectroscopy at low surface-brightness.



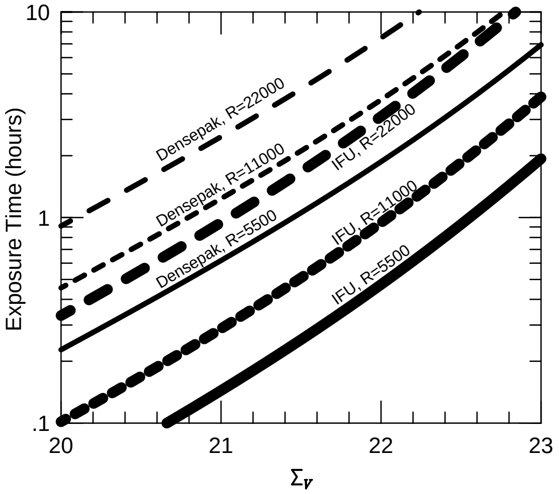


Figure 1. Figure 2.

Figure 1. Focal plane design of Spider integral field unit to be installed during the commissioning phase for the HET MRS (mid-1999). The fiber cores are 200 μm (1 arcsecond) in diameter with a 20:3:3 core to clad to buffer ratio. **Dark fibers** (45 fibers) are science fibers that go through to the spectrograph; **open fibers** are short (2.5 cm) packing fibers that maintain mechanical rigidity. Six sky fibers (not shown) will be mounted on an independently positionable probe.

Figure 2. Surface Brightness (Johnson V, assuming sky is $\Sigma_V = 21.9$ arcsecond^{-2}) versus exposure time needed in order to reach a signal to noise of 10 per resolution element for Spider (1 arcsecond fibers on the 9m HET) and the DensePak fiber array (3 arcsecond fibers on the 3.5m WIYN telescope; Barden & Wade 1988) at resolutions of 5500, 11000, and 22000. **The IFU will be able to reach $\Sigma_V = 22$ arcsecond^{-2} at resolution of 11,000 in one hour.**

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