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The Hawaii Imaging Fabry-Perot Interferometer (HIFI)

Jonathan Bland
Rice University, Houston TX 77251-1892
Gerald Cecil
Institute for Advanced Study, Princeton NJ 08540
Brent Tully
Institute for Astronomy, Honolulu HI 96822

At Mauna Kea Observatory, we have conducted optical, imaging spectrophotometric studies of selected active galaxies using the both the Canada-France-Hawaii 3.6m and University of Hawaii 2.2m telescopes (Tully, Bland & Cecil 1988). To maximize spatial resolution, we select galaxies independent of luminosity but known to possess interesting morphologies or high-velocity, extranuclear ionized gas (Walker 1968; Rubin & Ford 1968). We study both the large-scale patterns produced in IR-luminous, starburst systems (e.g. M82, NGC 253, NGC 6240) and those with compact, but spatially extended, circumnuclear, narrow line regions (e.g. M51, NGC 1068, NGC 4151). Current studies are restricted to the optical [SII], [NII] and [OIII] lines and the brightest Balmer recombination lines. These lines are, in principle, sufficient to constrain the dynamical structure and dominant excitation mechanism of the ionized component.

The HIFI system provides high kinematic resolution for a field-of-view as much as 10′ at subarcsecond increments matched to the seeing above the site. Our approach differs from the TAURUS systems (Taylor & Atherton 1980) in the use of large free-spectral-range etalons (~ 100Å) with high finesse (60), and low read-out noise ($\sim 5e^-$) CCD detectors at the image plane. (For further details, see Bland & Tully 1989). Extranuclear emission line widths in NLRs can exceed 3000 km s^{-1} which necessitates an interorder separation in excess of 4000 km s^{-1} to avoid confusion. In a typical night, $\sim 10^2$ spectrophotometric images are obtained over a few emission lines. The large format detector arrays ($800 \times 800 \rightarrow 2048 \times 2048$) give rise to enormous data cuboids ($I(\alpha, \delta, \lambda) \sim 1$ Gbyte) that require sophisticated data handling capabilities. During the past four years, reduction packages have been developed for and are currently operating on SUN/3 and SUN/4 series workstations at Rice, Princeton and Hawaii. The data calibration and reduction steps are well defined (Bland & Tully 1989). However, the optimal method for visualizing these multidimensional data structures is largely unresolved.

Major results have already been presented for some well known systems: in particular, M51 (Cecil 1988), M82 (Bland & Tully 1988), NGC 1068 (Cecil, Bland & Tully 1989; Bland *et al.* 1989), NGC 4151 (Cecil, Bland & Tully 1987), NGC 4258 (Tully, Bland & Cecil 1988). At this conference, two papers are presented for NGC 1068 which adequately demonstrate the power and versatility of the HIFI system. Sokolowski, Bland & Cecil have studied the large-scale disk at the CFH 3.6m telescope across a region spanning 160″ by 100″ (11.6 kpc × 7.4 kpc). The kinematics of the ionized gas display complex patterns which are well understood in terms of elliptic streaming motions (Bland *et al.* 1989). These motions, which we presume are driven by the stellar bar recently observed at 2μ (Scoville *et al.* 1988; Thronson *et al.* 1989), are presently being modelled by Athanassoula. This galaxy exhibits the clearest evidence to date for streaming induced by a bar-driven, density wave, which gains further support from the relationship of the dust lanes to the CO emission (Planesas, Myers & Scoville, this conference), the 10μ emission (Telesco & Decher 1988), and the non-thermal radio emission (Wynn-Williams, Becklin & Scoville 1985). More interestingly, we find an unusually energetic phase of the ISM which permeates throughout the *entire* disk as indicated by [NII]/H$\alpha \approx 1 - 6$ with line widths FWHM > 200 km s^{-1} which is distinct from the population of HII regions with [NII]/H$\alpha < 0.5$ and line widths < 100 km s^{-1}. We propose two possible origins for the extended, high excitation gas involving either the active nucleus or the IR-luminous, molecular ring, both of these having comparable bolometric luminosities ($\sim 1.5 \times 10^{11} L_{\odot}$), which we anticipate will be resolved after the launch of ROSAT. In a complementary, high resolution study at the UH 2.2m telescope, Cecil has decomposed the extended NLR into three major, dynamically distinct components: one of these is centred on the nucleus; another arises from gas near systemic velocity; and the remainder comprises the high velocity gas. The morphology and dynamics of the high velocity component is explained as the terminus of a radiatively excited, outflowing nuclear wind with a mechanical luminosity similar to the ionizing luminosity of the active nucleus (Cecil, Bland & Tully 1989).

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