The Disk-Halo Interface in Edge-on Spirals

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We are studying the disk-halo interface in several edge-on spiral galaxies through extensive imagery in Hα and other emission lines from Diffuse Ionized Gas (DIG), also referred to as the Warm Ionized Medium (WIM). In addition, for the nearby Sc galaxy NGC4631 we have obtained X-ray observations with ROSAT, to map the distribution of hot (10^{6-7}K) gas in the disk and halo. Here we present initial results for two late-type spirals, NGC4244 and NGC4631.

It has been realized for some time now that the WIM in the Galaxy is an important component of the interstellar medium, with a volume filling factor $\sim$ 20% and a large vertical scale height, $\sim$ 1 kpc (Kulkarni and Heiles 1988, and Reynolds 1991). The widespread nature of the WIM is also confirmed in observations of the spiral M31, where we detect the WIM all along the spiral arms (Walterbos and Braun 1992). The large vertical scale height and the high spatial resolution attainable in the optical make this gas an ideal probe of the disk-halo interface. Energy and mass exchange between galactic disks and halos, due to the combined effects of supernovae and stellar winds from massive stars, either in the form of galactic fountains (Bregman 1980) or chimneys (Norman and Ikeuchi 1989) is thought to be an important process. Surprisingly few concrete data exist so far, however, to determine how common this process is, and under which conditions it occurs. Rand *et al.* (1990) and Dettmar (1990) mapped the WIM in the edge-on spiral NGC891 and found a thick Hα emitting gas layer, with structures reminiscent of those predicted in the chimney model from Norman and Ikeuchi. Walterbos (1991) did not find a similarly thick disk in NGC4244, an Sc galaxy with a much lower star formation rate than NGC891.

We have obtained new, deep Hα imagery of NGC4244 and NGC4631 with the 36" at KPNO in the spring of 1991 and 1992. The new data confirm the lack of a thick WIM layer in NGC4244. The z-distribution of the Hα emission has an exponential scale height of 200 pc, similar to that of the stellar light (Van der Kruit 1979). There is no evidence for a more extended distribution of WIM superposed on that. In NGC4631, on the other hand, the scale height of the ionized gas distribution is of order 1 kpc. The irregular shape of this galaxy and its inclination, 85°, make it difficult to directly interpret this number as an actual vertical scale height. Nevertheless, there is widespread diffuse gas, with various Hα kpc-scale filaments or chimneys, in the central region (Fig. 1). [SII] images of this galaxy show the typical increase in [SII] over Hα intensity ratio for the DIG above the plane with respect to the discreet HII regions. A full report of the results for these two galaxies will be presented elsewhere.

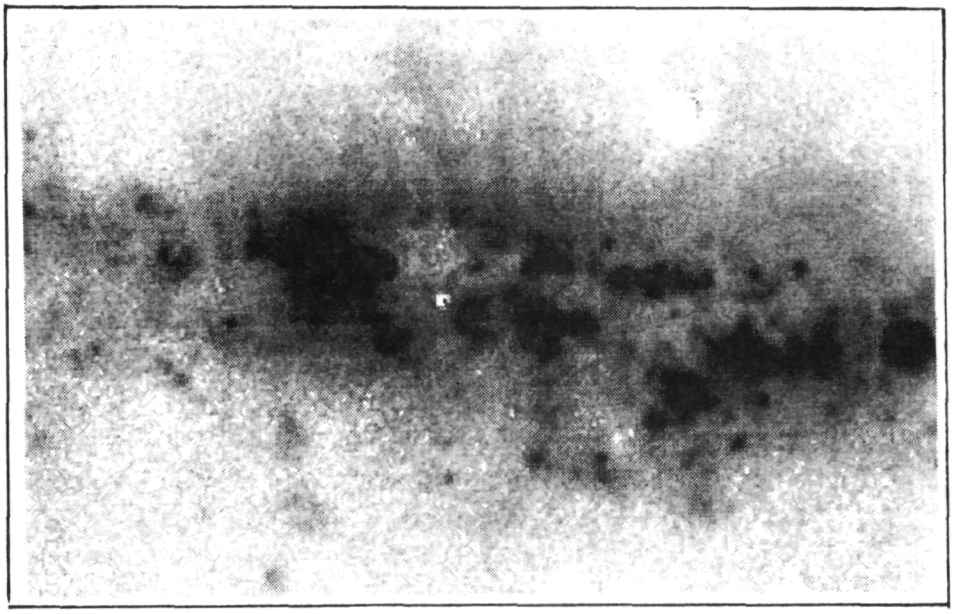

Fig. 1. The distribution of Hα emission in the central 6.9×4.3 kpc^2 region of NGC4631.

With its vigorous star formation activity, and its large radio halo (Hummel and Dettmar 1990) NGC4631 is one of the most likely nearby galaxies to show a halo of hot, X-ray emitting gas. We obtained deep ROSAT images of this galaxy and reproduce an initial image (based on a part of the total exposure) in Fig. 2. The X-ray emission from the disk of spiral galaxies is mostly contributed by (massive) binary systems. The strong point source in the disk of NGC4631 was already apparent in Einstein data (Fabbiano and Trinchieri 1987). The concentration of X-ray emission in the East part of the disk, however, may well coincide with the giant HI shell discussed by Rand *et al.* (these proceedings). Emission above the disk is not likely due to discrete sources. There appear to be three filaments perpendicular to the disk suggestive of outflow of hot gas from the disk into the halo. At lower levels there is also a strong suggestion in the data for a more extended diffuse X-ray halo, roughly of similar size as the optical disk of the galaxy, providing direct evidence for the elusive hot component of the ISM.

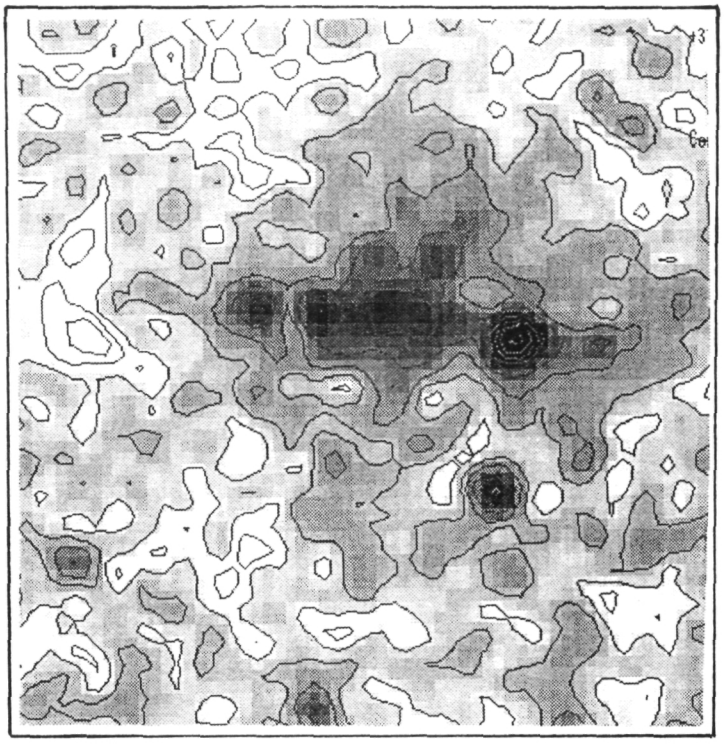

Fig. 2. ROSAT PSPC image of NGC4631, smoothed to a resolution of about 45″. The frame measures about 15′ (or 32 kpc) on the side. The exposure time was about 20,000 sec.

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