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The diffuse ionized interstellar medium perpendicular to the plane of NGC 891

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Introduction

The structure of the interstellar medium in galactic disks is very complex. Star formation processes affect the surrounding interstellar medium in galactic disks by means of energy inputs from stellar winds and supernovae. As a result of these processes the interstellar medium in the disk can connect to the galactic halo. One effect of this process is believed to be cosmic ray and hot gas leakage into the galactic corona, which is responsible for extended radio and X-ray emission above the plane.

This is described in terms of galactic fountains and loops by theorists and in terms of supershells and worm-structures by observers. Possible models depend on the energy input, gas temperature and density, and the presence of magnetic fields (e.g. Cox 1986).

Models of magnetic fields in galaxies show (e.g., Sawa and Fujimoto 1986) that axisymmetric magnetic fields in galactic disks can give rise to vertical field components. Such vertical components or Parker instabilities could build up magnetic flux tubes that possibly connect the processes within the disk to the halo.

Vertical magnetic fields could also explain observed vertical dust features which are most prominent in the edge-on galaxy NGC 891 (Sofue, 1987). Numerous dust filaments perpendicular to the plane are visible on plates taken under excellent seeing conditions. These dust structures can be traced out to 1.5 kpc above the plane. NGC 891 is a very promising candidate for studies of the so-called "disk-halo-connection" as it also possesses a thick radio continuum emitting disk.

In an attempt to study the structure and the properties of the diffuse ionized interstellar medium perpendicular to the plane of disk galaxies we have obtained Hα images and spectra of NGC 891.

Observations

Our spectroscopic data consist of two sets of observations. All of these data were taken with the Mayall 4-m telescope at Kitt Peak National Observatory [†]. The first set, obtained between 1977 and 1979, contains eight photographic spectrograms taken with the R-C spectrograph. These spectra have a reciprocal dispersion of 26 Åmm^{-1}. A second set of spectra was obtained in 1989 and consists of CCD spectrograms in two positions, taken with the echelle spectrograph and UV camera. With this instrumentation the reciprocal dispersion was 8.0 Åmm^{-1} at Hα.

In addition Hα images of NGC 891 were obtained in 1988 with the 42" telescope at Lowell Observatory. A 2:1 focal reducer was used with the f/8 secondary. A thinned 800x800 TI chip was used resulting in an image scale of ~0.8 arcsec/pixel. The Hα distribution was obtained by subtracting a scaled R band image from the image taken with the Hα filter.

Results

Perhaps the most remarkable property of the Hα emission line in NGC 891 is its extension out of the plane of the galaxy: we are able to measure the Hα line out to more than 30" (1.4 kpc) from

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the midplane. This means that the ionized hydrogen extends at least four times higher than the neutral hydrogen layer. An anomalously large scale-height for the ionized gas of $\approx$1 kpc is also found in the Milky Way (Reynolds 1989).

The echelle spectra show a changing ratio of [NII] to Hα. This excludes the possibility that the large scaleheight of the emission is due to scattering of disk emission by dust high above the plane. The z-extent of the Hα emission is confirmed by the imaging result. The large z-extent of the ionized gas is confined to the inner half of the visible disk. In this inner region the Hα distribution also shows a filamentary structure of the diffuse ionized medium. These filaments, sticking out of the plane, originate in HII regions in the plane.

The Hα image also shows a large scale asymmetry if the NE and SW parts of the disk are compared. The NE part is more prominent and extended in Hα. The same asymmetry is also seen in the radio continuum distribution (Hummel *et al.* 1989). This correlation between the diffuse ionized medium and the distribution of relativistic electrons is one example of a relation between star formation processes in the disk and the various components of the halo.

Thermal filaments or spurs which are related to HII regions are also known in the Galaxy (Müller *et al.* 1987). These filamentary structures perpendicular to the galactic planes may represent the *chimneys* which result in the supernova dominated model of the ISM by Norman and Ikeuchi (1989).

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