OPTICAL AND RADIO SURFACE PHOTOMETRY OF NGC 891

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ABSTRACT. A general correlation between the radio and optical continuum surface brightness has been found in the edge-on galaxy NGC 891. This suggests that the relativistic electrons are produced/accelerated in the vicinity of evolved stars or stellar remnants which have a spatial distribution similar to old disk stars. In this picture, the magnetic field required for the synchrotron emission is carried up from the disk to high Z through instabilities and star-forming activity in the plane.

1. Introduction

The possibility that a correlation may exist between the radio and optical continuum emission from the disks of spiral galaxies was first proposed by Allen (1975) from a study of the face-on spiral M51. This was corroborated by Van der Kruit (1977), and extended to NGC 6946 by Van der Kruit et al. (1977). In this paper, we use recent radio and optical observations of NGC 891 to test this correlation in an edge-on galaxy.

2. Observations and Results

We have obtained new, highly sensitive radio continuum observations of NGC 891 at 20-cm wavelength with the Westerbork Synthesis Radio Telescope and reconstructed the data into a high dynamic range map with an angular resolution of 16" x 12" (PA=0°) using the facilities of the National Center for Supercomputing Applications at the University of Illinois. The optical data were obtained by re-processing the Palomar Schmidt plates of NGC 891 ; this involved accurate astrometry within an rms error of 1".5 to fix the position of the optical image, removing disturbing effects of over a hundred stars to estimate the background and smoothing the image to the radio resolution of 16" x 12". We then examined the correlation between the optical and radio images within a box of size 200" x 300" centered on the nucleus, with the long axis of the box parallel to the minor axis of the galaxy. A strip ~ 25" wide along the major axis was excluded to avoid the dust lane. In the remaining "high-

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Z" region, the radio and optical surface brightnesses were compared at each pixel for radio brightness >1 mJy beam^{-1}, while strip-averages were used for fainter levels (strips about 14" x 200" parallel to the major axis). In Fig 1 we show the correlation extending over a range of three orders of magnitude in surface brightness. At any given pixel position, the ratio of radio to optical surface brightness at high Z in the central regions of NGC 891 is constant to within a factor of about 2.

3. Discussion and Conclusions

The correlation suggests that the volume emissivity of synchrotron radiation at radio wavelengths is proportional to the volume density of light, and presumably the mass density, of the old disk stars in normal spiral galaxies. Models involving the production of relativistic electrons from Type II supernovae in the plane of the galaxy and subsequent diffusion to high Z cannot explain the observed correlation without invoking additional assumptions. Instead, we propose that the relativistic electrons are produced in the immediate environment of evolved stars or stellar remnants which have a spatial distribution similar to that of old disk stars. Subsequent acceleration may occur locally, at high Z, by turbulence in the magnetized interstellar medium. The source of energy for this turbulence could be the star formation activity in the galactic disk, which carries the magnetic fields to high Z through instabilities. Bright radio continuum emission would thus be associated with stronger magnetic fields at high Z. Evidence for this is already accumulating in the case of NGC 891 (see Sukumar and Allen, Hummel in this volume).

References

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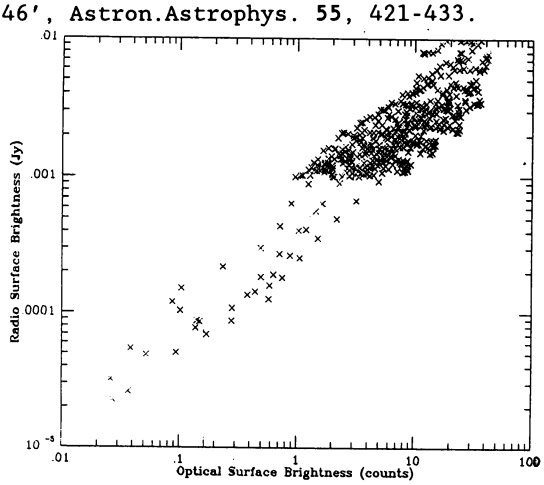

Fig 1. Correlation between the radio and optical surface brightnesses.

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