MORPHOLOGY AND SPECTROSCOPY OF MARKARIAN 231

J.B.Hutchings, Dominion Astrophysical Observatory,
5071 W. Saanich Rd, Victoria, B.C. V8L 4M6, Canada

S.G.Neff, NASA Goddard Space Flight Center,
Greenbelt, MD 20771, USA.

ABSTRACT

Deep optical imaging of Mkn 231 reveals twin (tidal?) tails, a linear nuclear feature at green wavelengths, and a very blue region 4 arcsec south of the nucleus. Much of the central part of the galaxy is red, but there are complex areas of blue luminosity outside this, and a sharp edge to the luminosity at a distance of ~16 arcsec from the centre. Overall, the host galaxy appears to have a normal optical luminosity and blue colour (B-R ~0.7) despite being one of the most luminous galaxies known in the infrared. Radio emission in the system is extended on one side on a similar scale to the optical tails, but shows no detailed correspondence with optical structure; in particular there is no radio counterpart to the optical 'jet'. Examination of IUE archival data indicate that the UV flux is very weak and the UV spectrum is peculiar for a Seyfert galaxy. The UV observations provide evidence for considerable nuclear extinction in the system, in accordance with previously published optical and infrared work, but the UV extinction is unlike Galactic absorption and may be more similar to that seen in the LMC. Recent optical spectra of Mkn 231 show changes in both the emission line spectrum and in the strong broad absorption lines (BAL), compared with previously published observations. This places strong limitations on the size of the nuclear continuum source. We suggest that Mkn 221 is a recently merged system which is currently undergoing star-formation, and discuss the connection with BAL QSOs.

DETAILS

Figure 1 summarizes the imaging results. The optical images were obtained at the CFHT prime focus in R, B, and intermediate band Green to detect [O III] emission. The radio image was obtained with the VLA B configuration, and shows little detailed correspondence with the optical, although it has a similar size scale. The radio image is unusual in being one-sided (see review by Wilson in this volume). The optical images clearly show twin tails, which suggest a recent merger of approximately equal mass galaxies. The inner structure consists of a reddened nuclear region and a very blue unresolved region 4 arcsec to the South. There is also an arc of blue luminosity to the West, suggestive of recent star formation. In Green light, a short feature is seen to emerge from the nucleus to the NE, not seen in the other colours: possibly this is a jet-like feature in [O III]. Allowing for reddening of ~2 magnitudes in the nucleus, the nuclear and galaxy absolute magnitudes are about -24 and -22 respectively (H_0=100). The high IR luminosity is probably reprocessed nuclear radiation.

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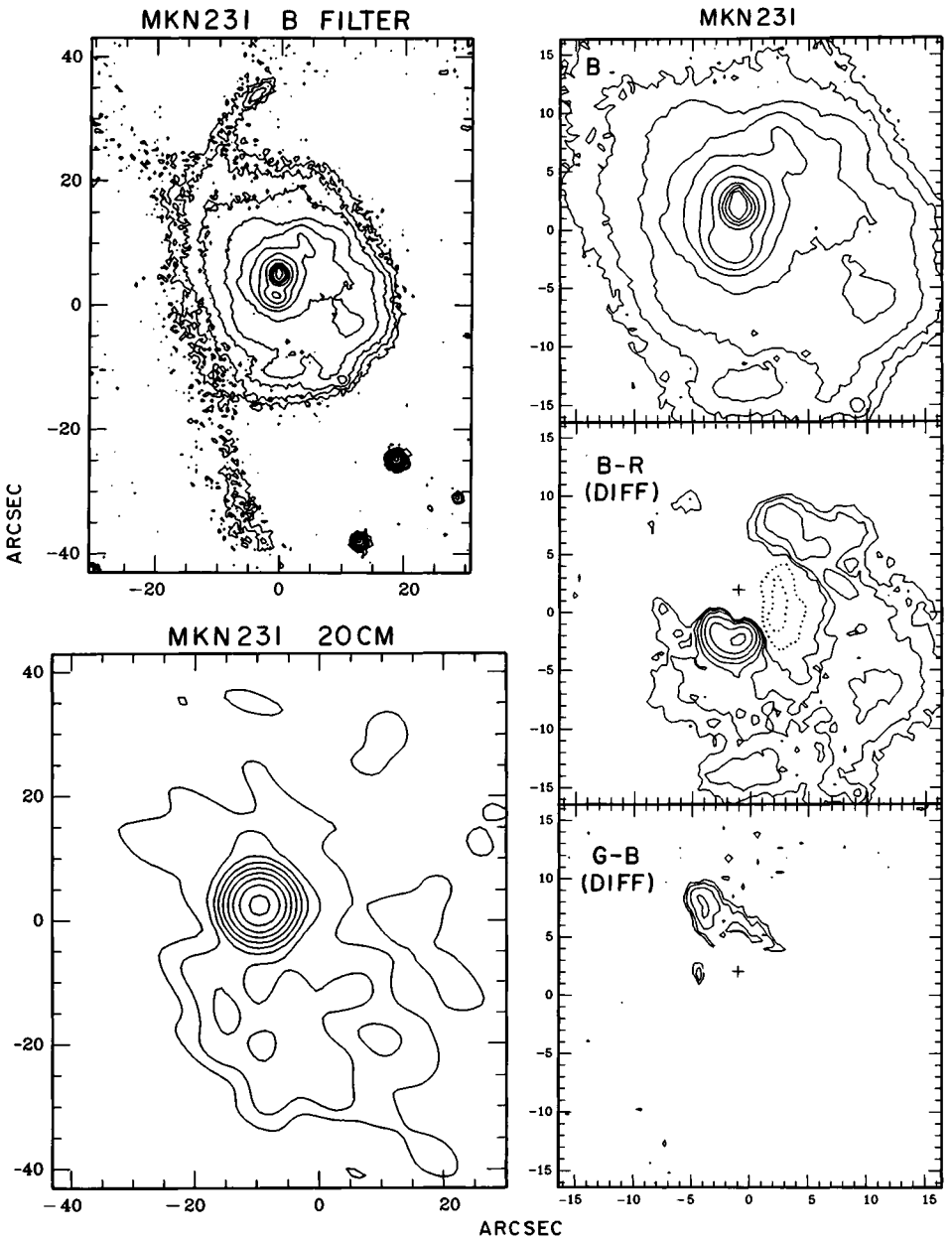

Figure 1. Images of Mkn 231. Scales match in left and right columns, and all contour levels are in steps of a factor two. Notice twin optical tails, and one-sided radio structure. Right column shows inner galaxy details. Lowest solid contour in centre panel has B-R index ~0.6. Cross marks nuclear position.

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The IUE UV spectrum of Mkn 231 is very weak, red, and contains no line features except Ly α. This too, suggests that the nuclear region is dust obscured. Whatever the observed UV source is, its reddening is anomalous in having no detectable 2200A feature - as seen in the Magellanic Clouds.

Optical spectra obtained at the DAO indicate changes in the Hβ and Ca II + He I absorptions since published observations taken in 1975. These are illustrated in Figure 2. Changes are seen at the $\geq 3.5\sigma$ level in the ~6500 and ~7500 km.s^{-1} velocity systems. These indicate that bulk displacements of order 10^{12} km are significant with respect to the size of the nuclear source, and hence support the accreting black hole scenario for this object.

Mkn 231 has been compared with the BAL QSOs because of the lines shown in figure 2. We are unable to see whether there are BAL lines in the UV, presumably because of extinction. However, two low redshift BAL QSOs (1411+442 and 1700+518) differ from Mkn 231 in not having reddened nuclei or optical band BAL profiles. None of the objects is edge-on. Thus, the analogy between Mkn 231 and BAL QSOs may be misleading, and at present we have no general scenario for the phenomenon.

These results are presented and discussed more fully in a separate publication.

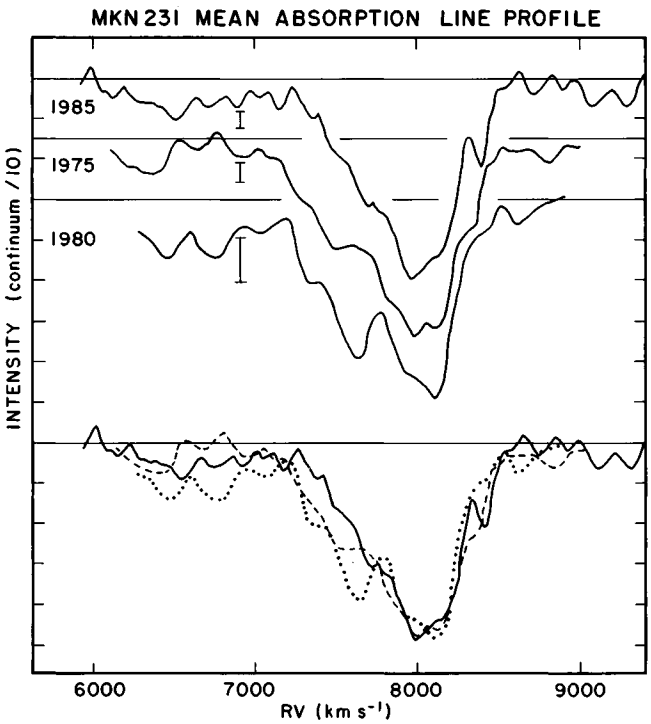

Figure 2. Absorption profiles in Mkn 231, showing possible changes in 5 and 10 years. Profiles of Ca II H, K, and He I 3888A have been combined in velocity space to increase S/N. Bars show noise full RMS amplitude. Lower plots are upper 3 superposed: solid 1985; dotted 1980; dashed 1975 from Boksenberg *et al* (M.N.R.A.S. 178, 451). 1980 spectra taken by Iye and Pritchet (private comm).

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