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XMM-Newton EPIC Observations of the Prototypical Starburst Galaxy M82

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Abstract. We present results from *XMM-Newton* EPIC observations of the prototypical starburst galaxy M82. We find that the superwind, as seen in X-rays, extends continuously from the starburst region to the X-ray emission associated with the Hα cap. We also find evidence for morphological features associated with superwind/IGM interaction, with some interesting correlations with HI emission.

Key words. ISM: jets and outflow – galaxies: individual: M82 – galaxies: starburst, galaxies: ISM-galaxies – X-rays: galaxies

1. Introduction

Starburst events are an important phase in galactic evolution and in the generation of cosmic structure. Starbursts within galaxies affect both galactic structure and evolution by heating and enriching the ISM via material outflow in a superwind. M82 is a nearby starburst galaxy (D = 3.63 Mpc) and is in many ways regarded as the prototypical superwind galaxy. M82 is very IR luminous, contains a substantial population of young supernova remnants and luminous HII regions, and many luminous super star clusters, all indicating a major and ongoing starburst.

We observed M82 with *XMM-Newton* on 2001 May 6 for 30.9ksec. Results from this observation have already been presented in Read & Stevens (2003) for the RGS data, and in Stevens et al. (2003) for the EPIC data. Here we focus on results on the extended X-ray emission associated with the superwind.

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2. EPIC Results

In Fig. 1 we show a combined (MOS+PN) and smoothed EPIC image of M82. In addition to the large number of point sources in the field, the main features to note are the bright nuclear region and the extended extraplanar superwind emission, predominantly bipolar in nature. The superwind emission is asymmetric, extending to a greater distance in the N than the S. For the N wind the emission extends nearly to the edge of the EPIC field of view. The enhanced emission in the N is coincident with the Hα 'cap' (Devine & Bally 1999), and there is an X-ray bridge connecting this to the main superwind emission. The X-ray emission associated with the Hα 'cap' also seems to be structured. In a three colour image of the emission from M82 (Stevens et al. 2003), in addition to some harder point sources in the field, much of the superwind emission is of a fairly consistent colour, implying little temperature change outside the inner region. Another interesting ht!

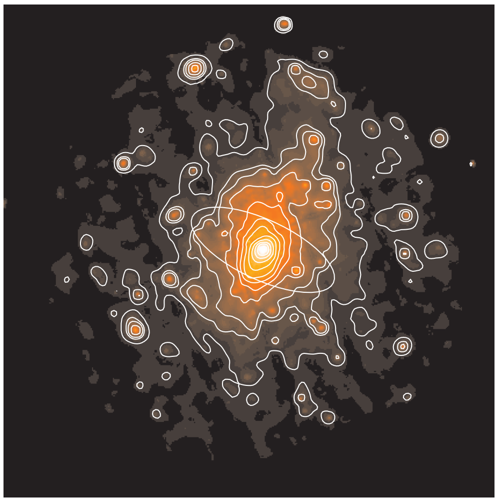

Fig. 1. The EPIC view of M82 in the 0.2 – 10keV waveband. The extent of the optical galaxy is shown by the ellipse. N is up and E to the left.

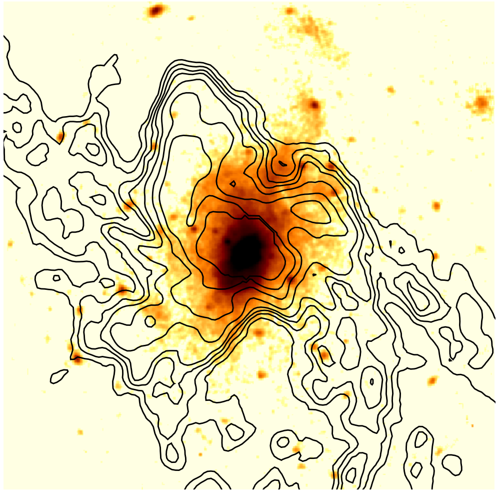

Fig. 2. HI contours (Yun et al. 1994) superimposed on the M82 EPIC image.

morphological feature in Fig. 1 is a ridge-like feature in the SE portion of the wind. Similar ridge-like features in the X-ray emission from superwinds have been seen in NGC 253 for example. In the N wind there is a region with a deficit of emission, which we term the 'dark lane', which is well correlated with HI emission.

There are some striking correlations between the X-ray emission and the HI emission shown in Fig. 2. For example, an apparent 'hole' in the HI emission is visible to the NW of the galaxy, coincident with the N wind. It is likely that the hot X-ray wind, in travelling out into the IGM, has blown this hole in the intervening cold neutral material. Note though, that the HI features have masses comparable to those implied for the superwind, and so could provide a substantial obstacle for the outflow. A large HI feature to the east of the N wind appears to be sharply bordered by X-ray emission from the superwind, and may be collimating the flow. The 'dark lane' in the X-ray emission in the N wind seems also to be associated with enhanced HI emission, and could be due to either absorption by foreground HI or due to an interaction, though which is not clear.

Spectral fitting to the EPIC data yields a model with two thermal components ($kT \sim 0.4 - 0.5$ keV and $\sim 0.7 - 0.9$ keV) and a power-law component, and a wind metallicity of $0.3Z_{\odot}$. These fits yield wind mass estimates of $3 \times 10^7 \eta^{1/2} \mathrm{M}_{\odot}$, where η is the volume filling factor.

In summary, here we have presented a few results on the EPIC observations of M82, yielding new insights into superwind structures.

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