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The M82 Outflow: X–rays as a Probe for Neutral Disk Gas

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Abstract. We present an analysis of X–ray absorption in the nearby starburst galaxy M 82. The X–ray attenuating column densities in the northern part of the M 82 outflow can be associated with cold disk gas detected in maps of HI and CO(1→0). We derive an X_{CO} factor which is somewhat lower as compared to that in our Galaxy. This is in good agreement with multi–transition line studies of various molecules in the disk of M 82.

1. Introduction

Starburst galaxies exhibit high star formation rates within relatively small areas. Consequently, large amounts of mechanical energy are dumped into the ambient interstellar medium heating it up to temperatures of 10^{6-7} K. This phase can be observed in X–rays out to distances of a few kpc along the minor axes of their hosts (for a review see, e.g, Heckman 2002; Strickland et al. 2002). The X–ray emission is absorbed by an internal (and a Galactic) cool component and this can be used to independently determine the column density of molecular hydrogen in the disk and halo.

2. X_{CO} Determination in M 82

We use archival X–ray data of the "archetypical" starburst galaxy M 82 obtained by the Chandra X–ray observatory (ACIS–I) for a spectral analysis of the hot gas streaming along its minor axis (see Figure 1). The data was calibrated and processed with standard CIAO routines followed by a spectral fitting of individual regions (excluding point sources). We used a Raymond–Smith plasma model with photoelectric absorption by the Galaxy and M 82 itself. In addition, we obtained VLA HI (B and D–array; D–array data previously published by Yun, Ho, & Lo 1994) and OVRO CO (1→ 0) data (Walter, Weiß, & Scoville 2002). The CO luminosity $L(CO)$ was converted to H_2 column densities (N_{H_2})

using the X_{CO} factor ($N_{H_2} = X_{CO} * L[CO]$). Comparing the sum of the H I and H_2 column densities with the X–ray absorbing columns shows that the northern part of the disk of M 82 points toward the observer (Fig. 1), in agreement with reddening and polarization observations (Notni & Bronkalla 1983; Chesterman & Pallister 1980). A Galactic X_{CO} of 1.6×10^{20} cm^{-2} (K km s^{-1})$^{-1}$ (Hunter et al. 1997) appears to overestimate the X–ray absorbing columns. A better agreement is provided by an X_{CO} of 0.5×10^{20} cm^{-2} (K km s^{-1})$^{-1}$ which was already suggested by Weiß et al (2001) using Large Velocity Gradient models of multi–transition data of various molecules in the central region of M 82.

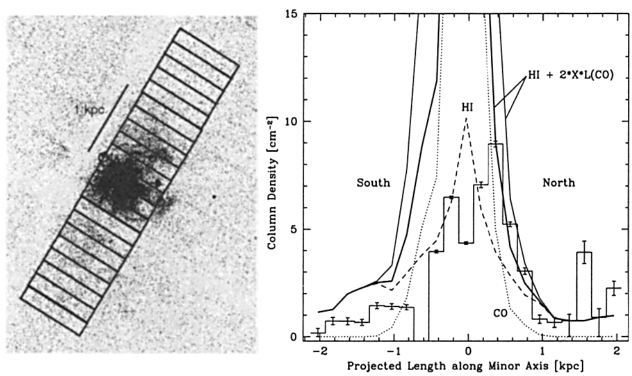

Figure 1. **Left:** Chandra ACIS-I data of M 82. The boxes mark the regions from which the individual spectra were extracted. **Right:** The absorbing column densities of the X–ray emission along the minor axis of M 82 are plotted as a histogram as a function of position. Overlaid are the H I (*dashed line*) and CO data (*dotted line*) as well as the proton distribution for which the CO luminosities were converted to H_2 column densities (solid lines) using X_{CO}. Two different X_{CO} factors were applied: 1.6 and 0.5×10^{20} cm^{-2} (K km s^{-1})$^{-1}$ (*thin and bold solid lines, respectively*). The lower X_{CO} conversion factor is in much better agreement with the X–ray absorption measurement.

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