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The Cool Atomic Gas in the Large Magellanic Cloud

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1. Introduction

Studying the cool atomic phase of the interstellar medium is of special significance as cool atomic clouds can become the raw material for star formation and so determine the evolution of the whole galaxy. The cool atomic interstellar medium of the Large Magellanic Cloud (LMC) seems to be quite different from that in the Milky Way. In three 21 cm absorption line surveys using the Australia Telescope Compact Array (ATCA)* the physical properties of the cool atomic hydrogen in the LMC and the halo of the Magellanic Clouds have been studied. Here we present the results of the third HI absorption line survey. A detailed investigation of the cool HI has been done toward the supergiant shell LMC4, the surroundings of 30 Doradus and in the direction of the eastern steep HI boundary. The data have been compared with survey 2 (Dickey et al. 1994) to probe the cool gas fraction for these different regions of the LMC and to study the differences of the cool atomic phase of the LMC and that of the Milky Way.

2. Observations

The 21 cm absorption line survey has been done toward 20 compact continuum sources, which have been selected from our ATCA snapshot survey at 1.4 GHz (Marx et al. 1997). The sources show peak flux densities between 21 mJy and 80 mJy. For the spectral line observations we used the single 6 km configuration

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(6D) of the ATCA. The resulting synthesized beamwidth is $\sim 7''$, the velocity resolution is $\Delta v = 1.65$ km s^{-1}. We have integrated two to seven hours on each source depending on the continuum flux density. This provides an optical depth sensitivity σ_τ between 0.1 and 0.25.

3. Results

We have identified 20 absorption features toward nine of the 20 lines of sight. The 30 Doradus complex shows an unusually large amount of cool HI, about half of the atomic neutral hydrogen. No other galaxies are known to possess regions with such high fractions of cool HI gas compared to the warm. The cool gas in the vicinity of 30 Doradus shows a complex dynamic structure even beyond the optical part of this giant star forming region. Whereas all lines of sight toward the 30 Doradus complex show cool HI clouds, only about half of the lines of sight toward LMC4 reveal HI absorption features. Cool HI clouds have been even less frequently detected in direction of the eastern steep HI boundary. The number of detected cool HI clouds and their properties, such as the optical depth or the absorption integral, suggest a higher cooling rate near LMC4 and 30 Doradus compared to reference positions, caused by an enhanced density near shock fronts. We do not find a statistically significant enhancement of cool clouds toward the eastern boundary of the LMC, in spite of an expected compression zone due to the motion of the galaxy through the halo of the Milky Way (Mathewson & Ford 1984). But the detected cool HI clouds at the leading edge differ from atomic clouds at reference positions by higher values of the optical depth and the absorption integral, which seems to indicate a higher cooling rate of gas behind a large shock on the east side.

Comparing the cool atomic phase of the LMC with that of the Milky Way we find: HI clouds in the LMC are either unusually cool ($< T_c > \approx 30$ K) compared to the cool phase in the Milky Way ($< T_c > \approx 60$ K, Kalberla et al. 1985), or the cool atomic phase of the interstellar medium is more abundant in the LMC ($f_c = 35\%$ for $T_c = 60$ K) relative to the warm neutral medium than in our Galaxy ($f_c = 24\%$ for $T_c = 60$ K). Even if we exclude lines of sight toward the 30 Doradus complex and toward LMC4 we find, assuming $T_c = 60$ K, a similar mixture of warm and cool interstellar phases compared to that in the Milky Way, despite the completely different radiation field, heavy element abundance and dust-to-gas ratio in the LMC.

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