Optical Studies of a Local Filament Toward the Magellanic Clouds and a Local IVC Region

B.E. Penprase[1], Q.D. Wang[2], and U. Herbstmeier[3]

[1] Pomona College, 610 N. College Ave, Claremont, CA 91711, USA
[2] Department of Astronomy, NWU, 2145 Sheridan Road, Evanston, IL 60208, USA
[3] MPI für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

Abstract. We present new spectroscopic results which constrain the distance of a large IR emitting filament near the LMC, as well as some new results for a local region with widely distributed detections of Intermediate Velocity Clouds (IVCs). We present spectroscopic observations of stars toward both regions which constrain the distances and kinematics of the interstellar features. New optical high resolution ($\lambda/\delta\lambda \simeq 10^6$) spectra have been obtained for the star HD 22252, and are used to estimate approximate distances, temperatures, and pressures within the cloud. An unusual local region of the interstellar medium with several IVCs is also reported, with multiple components of absorption from -80 $< v_{\rm LSR} <$ 70 km s^{-1} seen toward several stars in the region.

1 Optical Detection of Absorption from a Local Filament Toward the Magellanic Stream

The filament in our study is a very bright object in the infrared, and extends to high galactic latitudes in the little-studied part of the local bubble toward the Magellanic Clouds (see Figure 1). Radio observations of the object have been obtained previously by McGee et al. (1986), but these observations were not able to provide an estimate of the distance to the cloud. Previous observations (Penprase et al. (1997a)) have enabled us to constrain the distance to 110 pc, and the mean value of extinction to A_v=0.53 magnitudes. The filament has mean galactic coordinates of l=280^o and b=-45^o. Examination of the galactic plane maps from Frisch (1995) and the high latitude maps of Snowden (1993) places the object within the local bubble, and as such the filament is a valuable probe of the temperatures, and pressures within the local bubble. If the local cavity is completely filled with X-ray emitting hot gas, and if pressure equilibrium prevails within the local bubble, then measurements of the pressure for this filament will provide an independent method of measuring the pressure of the hot component of the ISM. We discuss below some constraints on the pressure of the filament, and possible implications for the local bubble.

We have estimated the linear sizes of clumps within the filament, which range in size from 0.15 to 0.75 pc, based on the resolved features seen in *IRAS* maps of the region. The pointings in McGee et al. (1986) include a wide range

https://doi.org/10.1017/S0252921100071414 Published online by Cambridge University Press

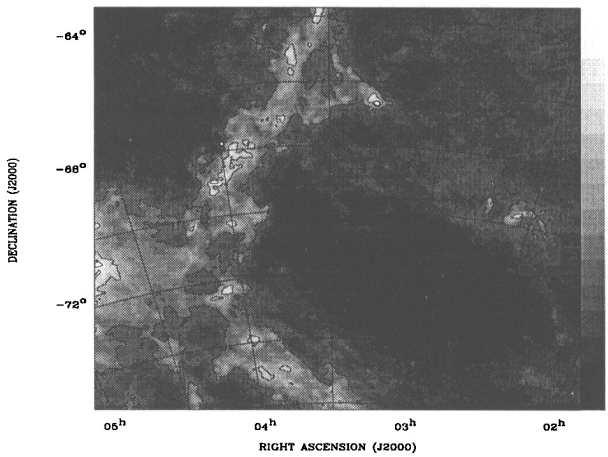

Fig. 1. *IRAS* 100 μm image of the filament, at the distance of 110 pc (Penprase et al. (1997a)), showing an X-ray shadowing region at center right.

of observed column densities, with 0.5×10^{19} cm^{-2} < N(HI) < 2.0×10^{20} cm^{-2}. For simplicity, we have adopted an average H I column density of $< N(HI) > = 10^{20}$ cm^{-2} from these H I emission measurements, and initial examination of the H I 21 cm absorption observations appear consistent with this estimate.

By combining our value of total H I within the filament with the computed linear dimensions, we may derive estimates of the density within the filament, which range from $50 < n_H < 200$ cm^{-3}, using a conservative estimate of the size of the clumps within the filament which corresponds to cloudlet dimensions of 0.15 to 0.60 pc. Recent observations (some presented at this conference) suggest that the cloudlets could be much smaller, and therefore the above density estimates are probably lower limits to the actual density within the cloud.

New spectroscopic observations have been obtained for both NaI D and Ca II K absorption using the UHRF at the AAT (Penprase et al. (1997b)), and with the resolving power of $\lambda/\delta\lambda = 10^6$, it is possible to constrain the temperature within the filament using the observed resolved linewidths of the optical absorption lines. One of the spectra from the AAT is shown in Figure 2, for the target star HD 22252 (d=120pc), which is at a distance of 120 pc. Analysis of linewidths suggests temperatures within this filament ranging from 200 < T < 750 K. Examination of the linewidths from the 21 cm absorption profiles (which were of lower resolution than the optical lines) results in a weaker upper limit of temperature consistent with this result, at T < 700 K.

The spectra suggest that the pressure nT of the cloud ranges from 10^4 < nT < 10^5 cm^{-3}K, which is comparable, and possibly higher than, the estimated pressures within the local bubble, which are typically reported to

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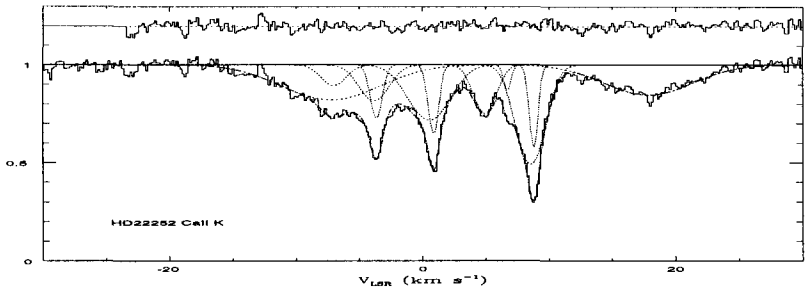

Fig. 2. AAT UHRF Ca II spectrum for HD 22252, showing over 10 separate components of absorption for a local bubble sightline.

be nT = 10^4 cm^{-3}K. Soft X-ray cloud shadowing for a portion of the filament has been detected in ROSAT PSPC data (Wang and Yu (1994)), and so the filament would be expected to be in contact with the hot gas within with the local bubble under the McKee-Ostriker model. Since it is likely that the filament has much smaller and denser structure than is visible within the *IRAS* data, the pressures of the filament could be significantly greater than the hot gas pressure within the local bubble.

If the pressure of the filament is higher than the hot gas pressure, the filament could be in transient dense state, and expanding into the local bubble. Alternatively, stability of the high pressure filament could imply a magnetically confined region of the interstellar medium. Further observations are being planned to resolve the small scale structure of the cloud, and to search for evidence of magnetic fields within the filament. For the upper range of our pressure estimates, the magnetic field required for confinement would be within the range of $B \simeq 70 - 140\,\mu$G. This strong magnetic field should be detectable through radio continuum observations.

2 Studies of a Local IVC Region

The second region we consider briefly is in the same quadrant of the galaxy, at galactic coordinates l=280^o, b=11^o. Adjacent to the region are two high velocity clouds, HVC279.5+10.7 and HVC279+13, which were observed to have HI velocities of +185 km/s. Since most HVCs appear to be moving towards the galaxy, these HVCs are somewhat anomalous. In an earlier paper (Penprase and Blades (1992)) it was found that the nearby star HD 93721 shows extremely complex optical absorption, with over 10 components of absorption between -65 < v_{LSR} < 75 km/s in the Ca II spectrum. While large deviation velocities from galactic rotation are expected in this direction, the detection of these features toward a star at d = 410 pc appears to imply highly unusual kinematics for this part of the interstellar medium.

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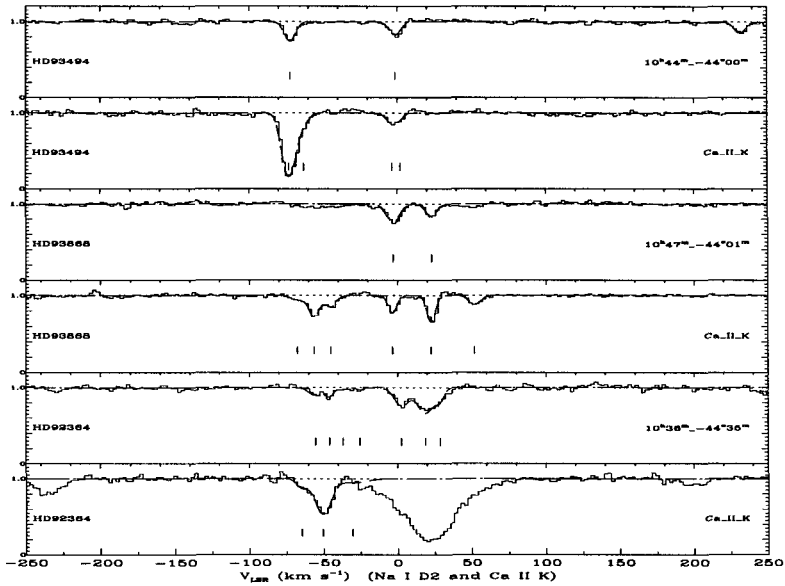

Fig. 3. Three pairs of Na I and Ca II absorption spectra for the stars HD 93494 (top), HD 93868 (middle), and HD 92364 (bottom), showing clear evidence of IVC components.

Figure 3 shows new high dispersion Na I and Ca II absorption spectra for three of five newly studied additional stars in the region. These spectra show high S/N detections of several additional IVCs, with -85 $< v_{\rm LSR} <$ 30 km/s. The distances of the three stars in Figure 4 are (from top) 250, 260 and 350 pc, confirming that the IVCs originate from the local ISM. These spectra help preclude a circumstellar origin for these features, and give further evidence that these components result from a widespread disruption of the interstellar medium in the region.

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