THE HOT COMPONENT OF THE INTERSTELLAR MEDIUM

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Revolutionary changes in our awareness of the physical state of gases in interstellar space have been precipitated by new theoretical realizations and observational evidence. Mechanical energy released by supernovae and early-type stars is now thought to be an important source of heating and agitation for the interstellar medium (McCray and Snow 1979). The propagation and dissipation of this energy gives rise to a broadly distributed network of gas at low densities and high temperatures, revealed to us by its emission of soft x-rays (Cox 1977, Tanaka and Bleeker 1977) and the pervasiveness of highly ionized atoms (with O VI being the most conspicuous tracer, see York 1974, Jenkins and Meloy 1974, review by Jenkins 1977).

From studies on the evolution of supernova remnants and their interaction with the surrounding medium (Chevalier 1977), it is clear that there can be a significant production of gas with $T \gtrsim 10^6$K. Cox and Smith (1974) (see also Smith 1977) pointed out that the rate of explosions in our galaxy is high enough that new remnants overlap the edges of old ones before they break up and dissipate, thus allowing the gas to be reheated before it has a chance to cool radiatively (the cooling time is about 10^7 yr. at normal interstellar pressures; see, e.g. Shapiro and Moore 1976). As suggested by McKee and Ostriker (1977), the blast waves propagate through a medium consisting of dense but well separated clumps of gas, rather than a medium of nearly uniform density, and hence the effects from such disturbances could be more far reaching than previously assumed. From the viewpoint of this theory, most of the volume of space may be dominated by the high-temperature phase. The losses which counterbalance production are probably attributable to interactions with the normal, cool phase of gas, through the mechanisms of thermal conduction and evaporation or condensation flows (Cowie and McKee 1977). Also, some loss could occur if the gas is driven off as a galactic wind (Field 1975).

Castor, McCray and Weaver (1975) (see also Weaver, et al 1977) developed a theory on how the hot gas could be produced within a quasi-stationary shock zone where a stellar wind slams into the ambient medium

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surrounding an O or B type star which is rapidly losing mass. While this model has some important implications on the material in the vicinity of young stellar associations, it is unlikely that the observations of O VI absorption lines are dominated by the shocked gas surrounding the stars being observed (Jenkins 1978a).

While the column densities of O VI observed with the Copernicus satellite (Jenkins 1978b) show a convincing correlation with path length, there is a large scatter in the relationship, indicating that there are strong irregularities in the distribution of hot gas. The fluctuations are consistent with the Poisson statistical variations from a population of approximately 6 regions per kpc, each with a column density of 10^{13} ions cm^{-2} (Jenkins 1978c). For about 10% of the stars observed, much thicker parcels of hot gas are observed. The degree of irregularity in the O VI results closely mimics that of ordinary H I gas in the interstellar medium. The velocities of the O VI regions show a dispersion of about 25 km s^{-1}, which is well below velocities expected for material behind a shock which is strong enough to heat the gas to greater than 10^5K. Either the gas has been slowed down after shock heating, or we are viewing evaporation zones on the surfaces of ordinary, low-temperature clouds (Cowie et al 1979).

From constraints imposed by the observed ratio of N V to O VI (York 1977) and limits on the thermal velocity dispersion, Jenkins (1978c) concluded that the temperature distribution for the electron density n_e could be characterized by the relation $dn_e/d\,\ell n\,T = T^{0.5 \pm 0.5}$ for the gas with $4.7 \lesssim \log T \lesssim 6.3$ revealed by O VI absorption (soft x-ray observations sample to higher temperatures and may include gas with larger velocity dispersions as well).

From the temperature distribution and the average O VI density over all space, we can arrive at an average global density n_e of about 1 to 1.5×10^{-3} cm^{-3}. Perhaps the most difficult parameter to measure, however, is the average volume filling factor of this material (and hence the true internal n_e within each region). From several indirect arguments, Jenkins (1978c) estimated that approximately 20% of space may be occupied by the O VI producing hot gas, but this result is very uncertain.

Stellar spectra recorded by the IUE satellite sometimes show Si IV and C IV absorption lines whose appearance suggests that they are of interstellar origin, but it is controversial whether or not these data are strongly contaminated by contributions from material very near the stars. These two ions are expected to have their maximum abundance at temperatures slightly below 10^5K. Savage and de Boer (1979) have shown evidence that some of the absorption must be truly interstellar, since they recorded distinct profiles with nearly zero velocity shift for stars in the Magellanic clouds. These stars and their surrounding material have positive velocities of a few hundred km s^{-1}. There is a strong hint from the detailed shape of the low velocity absorptions that some of the hot material containing these ions exist at more than several kpc from the plane of the galaxy.

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