HIGH-RESOLUTION SPECTROSCOPY OF ASTRONOMICAL OBJECTS

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This paper reviews recent advancements in the main astrophysics research interest of the Physics Department at QUB, that of high-resolution spectroscopy of astronomical objects. The major areas of study are early-type stars, the interstellar medium and emission-line regions of Seyfert galaxies and planetary nebulae. These are discussed separately in detail below.

1. Early-type stars

For a number of years we have been involved in an extensive study of OB-type stars at large distances (z) from the galactic plane. Initial work has shown that there are many stars at distances of typically 2 kpc from the plane, which have probably been accelerated out of the disc via close-binary disruption or cluster ejection (Keenan et al 1982, Keenan and Dufton 1983, 1984). Recently however, we have found a small number of stars (currently seven) which, on the basis of their kinematics and z-distances, appear to have been formed in the halo (Keenan and Lennon 1984, Keenan et al 1986a, b, 1987, Brown et al 1988). For example, a detailed model-atmosphere analysis of the star PHL 346 indicates a z-distance of 8.7 kpc and an age of 17 million years. When combined with an estimate of the current stellar velocity in the z-direction, PHL 346 would appear to have been formed at a distance of at least 6 kpc from the plane (Keenan et al 1986b).

Another research topic is the modelling of discrete, narrow absorption components detected in the spectra of mass-losing early-type stars (Bates et al 1982). Bates and Halliwell (1986) have developed an improved analytical treatment for the trajectory of gas parcels ejected from such stars, while Bates et al (1986a) and Halliwell et al (1988) have applied this to currently available Hα profiles and IUE observations of Mg II lines for β Ori. These authors concluded that their model was consistent with the observational data for this star, but that the data were not sufficient for a rigorous testing of the model.

The chemical composition of young star clusters and the galactic abundance gradient is also a substantial research interest of QUB personnel. However, it has been reviewed by Lennon (1987) and will, therefore, not be discussed here.

2. Interstellar medium

The importance of using weak absorption lines in interstellar abundance determinations is well known, as the lines tend to lie on the linear portion of the curve of growth, so that the resultant column density of a species depends only on the oscillator strength of the transition and the equivalent width. Over the past few years we have been involved in an extensive programme to calculate such f-values and use them in the analysis of interstellar observations obtained with the Copernicus satellite. To date we have analysed Copernicus data for interstellar Si II, Mg II, N I, O I and P II, and have found gas-phase depletions and hence grain compositions which are significantly different from those derived previously (Dufton et al 1983, 1986, Murray et al 1984, Hibbert et al 1985, Keenan et al 1985, 1986c).

In addition to the above, QUB personnel are also investigating the distribution of high-velocity interstellar clouds (HVC) using high-resolution IUE and optical spectra. This study has concentrated on sightlines in the galactic direction l ~ 100°, b ~ −7°, and has revealed the presence of several red-shifted components with velocities up to ~100 km s−1 (Bates et al 1983, 1984, Keenan et al 1986d). Recent work has shown that there appears to be a correlation between the HVC regions and those areas which show strong far-infrared (IRAS) dust emission, although there is no clear evidence at present
for identifying the HVC gas directly with the infrared emission (Bates et al 1986b, 1988).

As part of a continuing programme to determine the nature and extent of early-type stars in the galactic halo (see Section 1), we have obtained high-resolution observations of interstellar Ca II absorption lines towards several several distant, high-galactic-latitude stars. A comparison of these data with Ca II equivalent widths for extragalactic sightlines implies that there is a significant amount of this species out to $z \simeq 1$ kpc, but not much beyond $z \simeq 2$ kpc (Keenan et al 1983, 1988).

3. Emission-line objects

Extensive observations of emission lines in Seyfert galaxies and planetary nebulae have recently been performed using the high-resolution QUB echelle spectrograph with the RGO CCD camera on the 1-metre JKT (McKeith 1986, Barnett and McKeith 1986, McKeith et al 1987). Currently these data are being analysed to provide information on the line-emitting regions, such as estimates of the electron densities in planetary nebulae from the O II 7318.6A/7319.9A intensity ratio (Barnett and McKeith 1988).

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References