As part of a programme to study their multi-wavelength properties, we obtained optical spectra of 19 NSLS with the IDS mounted on the INT. In this paper, we present the results of a study of the 23 optical doublets of these objects, from which we derive their emission line properties. A comparison of these results with those obtained with other instruments shows that the optical doublets can be used to identify the NSLS.

**Abstract**

We present optical doublets of NSLS with the IDS mounted on the INT. These doublets allow us to study the properties of the NSLS and to determine their emission line properties. We find that the optical doublets of NSLS are similar to those of active galaxies, and we believe that they are responsible for the emission line properties of NSLS.
2 X-ray Emission and Coronal Lines

For each NLS1, we measured the strength and redshift of the strongest optical coronal lines, including [Fe VII] $\lambda$6087, [Fe X] $\lambda$6374 and [Fe XI] $\lambda$7892. The Hydrogen and Helium permitted lines along with several lines emitted from the NLR, including [O III] $\lambda\lambda$4959, 5007, were also quantified.

![Diagram](image)

Fig. 1. The equivalent width of [Fe X] $\lambda$6374 versus the power-law photon index derived from ROSAT PSPC data.

In a previous study of AGN known to have coronal lines (3), it was found that the objects with the largest equivalent widths of coronal-line emission were those with the steepest soft X-ray spectra, based on power-law fits to the ROSAT PSPC data. In Figure 1 we show the equivalent width of [Fe X] $\lambda$6374 versus the photon index, $\Gamma$ (taken from the literature). No correlation is seen and a wide range in coronal-line strength is observed for a given power-law index.

3 Kinematics

The exact location of the coronal line region is unknown, but it is believed to lie between the BLR and NLR, possibly associated with the dusty torus.
Fig. 2. The velocity of the Fe coronal lines relative to [O III] λ5007 versus the radial estimator (defined in the text). A best-fit line allowing for errors in both variables is also shown.

invoked in AGN unification models (4). As resolving the coronal-line region via direct imaging is difficult, to place some constraints we measured the FWHM and redshift of the coronal lines relative to the strong NLR line, [O III] λ5007. Assuming the line widths are governed primarily by orbital motion, we define a ‘radial estimator’, \( R \), such that

\[
R = \frac{r_{\text{Fe}}}{r_{\text{O III}}} = \left( \frac{\text{FWHM}_{\text{Fe}}}{\text{FWHM}_{\text{O III}}} \right)^2,
\]

where \( r_{\text{Fe}} \) and \( r_{\text{O III}} \) are the radial distances from the centre. In Figure 2 we plot the velocity of the coronal line (relative to [O III] λ5007) versus the radial estimator. A clear correlation is present such that broader coronal lines have larger blueshifts. The simplest interpretation is that the coronal-line gas is part of a decelerating outflow. The broader coronal lines also tend to have larger equivalent widths.
4 Conclusions

The lack of correlation between the coronal-line strengths and the ROSAT power-law indices is somewhat surprising given the predictions of photoionization models. It may be that the range in gas conditions or covering factors for the coronal-line regions between different NLS1s is quite large. The continuum shape may also be aspect-dependent, such that the steep soft X-ray continuum is not always seen by the coronal-line emitting gas. Finally, a single power law may provide a poor parameterization of the soft X-ray spectral shape. ASCA spectra of NLS1s do suggest a complicated spectral shape in some objects (5). The shape of the soft X-ray continuum in NLS1s will be accurately determined by forthcoming Chandra and XMM-Newton observations.

The kinematical results suggest a connection between the coronal-line emitting gas and the central region of NLS1s. In the context of a decelerating outflow model, the gas velocity is $\approx 500 \text{ km s}^{-1}$ at a distance from the centre $\approx 1/40$ that of the NLR. Given an NLR size $\approx 100$ pc, this implies that the coronal-line gas originates at $\approx 2$ pc from the centre. Such a small size could be associated with the outer region of the BLR and/or the inner edge of the proposed dusty torus.

References