The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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Using the IR variability of Seyferts

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Abstract. This paper describes some useful results that can be obtained through long-term infrared photometric monitoring of Seyfert galaxies.

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1. Observations

Some aspects of a long-term programme (up to 10000d) of infrared photometry through a constant aperture of 12 arcsec diameter are described. $JHKL$ variability data were obtained for a sample of 41 Seyferts, covering a factor of 1000 in luminosity, with observations typically 3–4 times per year.

2. Outline of results

2.1. *General behaviour of variability*

The amplitudes of variability are usually less at the shorter wavelengths covered than at the longer. This can be the result of dilution by an underlying galaxy component or of circumnuclear reddening. Those at K range from < 0.1 to > 1.1 mag. The timescale for changes is from about 1 week to a few years. Only two objects out of the 41, NGC2110 and ESO103-G35, may not have varied at all.

The infrared variations generally follow those in the visible and x-ray ranges, though with some delay.

2.2. *SEDs of the variable parts*

When the J, H, K and L values are plotted against each other in flux-flux diagrams it is found that they are linearly related. The implication is that the variable part of each galaxy has a well-defined SED, independent of its actual activity state. Furthermore, it is notable that the colours of the variable components of different galaxies tend to cluster around similar values (see Fig. 1). In particular, for unreddened nuclei, the H–K colours are appropriate to a temperature of 1600K, about the maximum attainable by refractory dust without subliming. This is further confirmation that the dust mechanism as the source of the near-infrared radiation.

2.3. *Nuclear reddening of variable parts*

When a galaxy has redder colours than normal, its E_{H-K} colour excess can be used to derive an A_V value according to an assumed extinction law (e.g., NGC1068, 5506, 526a, 2992, MCG-5-23-16 and Tol0109-36). The figures so obtained apply to the inner (hot) edge of the dust radiation zone.

2.4. *Constant components*

Further, from the flux-flux diagrams it is often possible to derive the contribution of the underlying galaxy within the measuring aperture, based only on an assumed colour for an 'inactive' galaxy, without appealing to any model for the radial distribution of surface

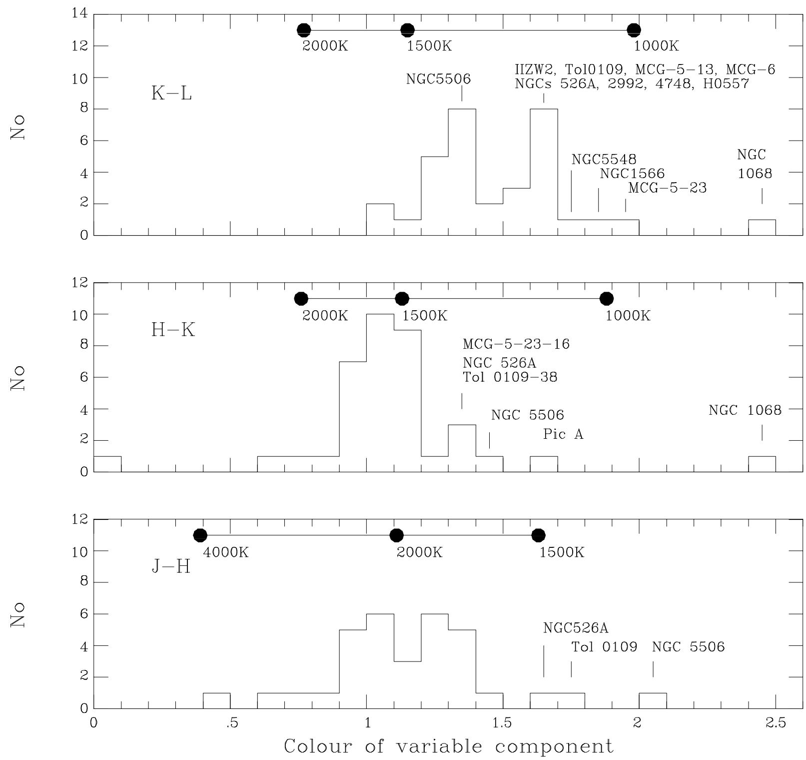

Figure 1. Distribution of IR colours of the variable components of Seyfert galaxies. Black-body colour temperatures are shown at the tops of each panel. Galaxies with circumnuclear obscuration show colour excesses.

brightness. Some of the most luminous members (H0557-383, H1143-182 and Mkn 509) of the sample show no evidence for normal galaxy contributions; i.e., they are essentially QSOs.

In many cases there is evidence that, besides typical stellar material, there is a constant circumnuclear dusty component such as might arise from a star-formation region.

2.5. *Delayed response*

Delays between the U or J and the L bands have been determined for many of the sample using the standard interpolation and cross-correlation method. The delays are longer and more reliably determined for the most luminous galaxies.

2.6. *Particular galaxies*

Additional examples of galaxies that have been studied are: F9, where the observations described by Clavel, Wamsteker and Glass (1989) have been extended to about twice their original duration (the several-hundred day delay between the UV and the infrared has persisted); NGC1068, whose L flux doubled in the time since monitoring began, and is now declining; and MCG-2-58-22, whose activity is now much lower than when it was discovered.

The full data have now been published (Glass 2004).

References

Glass, I. S. 2004, MNRAS, 350, 1049

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