AGN VARIABILITY STUDIES: AN AGENDA FOR THE NEXT MILLENIUM ?

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1. The very long term flux variations, and the rare transient events

Data which are obtained today can be re-acquired better and faster in the future. Their only enduring value, after they have been interpreted, is as historical markers. With electronic archiving one can envision archives covering decades, centuries and even longer periods of observations of selected objects or classes of objects. Such a data base would allow the study of phenomena with low temporal frequencies, and of rare events.

First hints of such phenomena in AGN have been discovered recently: 1) The Seyfert 1s, the best studied AGN at present, exhibit flux variations on time scales ranging from hours to several years (see Ulrich et al. 1997). The faster variations (up to months) have been extensively observed, and they are best understood as being caused by magnetic flares in the corona above the central part of the accretion disk (Blandford and Payne 1982). The origin of the long term and large amplitude UV/optical flux variations (factor 20 in several years as observed in NGC4151 and F9), however, remain essentially unknown.

2) Rare unexpected events have recently been recorded in the form of the appearance of broad emission lines in galaxies which had previously displayed moderate or no signs of activity (e.g. NGC 1097 and NGC 4552; Storchi-Bergmann et al. 1995, Renzini et al. 1995). This infrequent occurrence of transient energetic events is related in an as yet unclear way to the duty cycle of AGN and is made especially interesting by the growing evidence for a black hole in every large galaxy nucleus.

Y. Sofue (ed.), The Central Regions of the Galaxy and Galaxies, 99-101.

Both types of long term variations will benefit from time coverage extending over decades and centuries. The power spectrum of the long term variations could be compared to the predictions for various accretion mechanisms, thereby enabling the true mechanism to be identified. As for the rare events, one could witness “live” the accretion of minute objects such as stars or microclouds, and the passage of a given AGN from the “dormant” to the “working” stage.

Long time base observations are not the only way to study rare or slow phenomena. Statistics is another method of choice. Furthermore, other types of observations will contribute to our understanding of AGN long term variability. The most promising is long baseline interferometry which has the potential to uncover the details of star-by-star accretion and to map incoming flows. On the other hand, does the future hold some surprises in store for us which would shake the foundations of the current AGN paradigm?

2. Exploring the parameter space defined by black hole mass and accretion rate

In recent years two methods have been developed to estimate the mass of the central black hole in AGN: one is straightforward and is based on spatially resolved HST spectra, the other involves the observations of the time delay between the variations of the continuum flux and the variations of the broad emission lines intensity. Another important development has been the identification of subclasses of AGN with extreme values of the accretion rate: the Narrow Line Seyfert 1s, NLS1, which may be accreting at a rate close to the Eddington rate (Pounds et al. 1995) and, in contrast, the extremely weak AGN which evidently have a very low accretion rate. The AGN signatures in the latter category are weak broad emission lines, or direct or indirect evidence for the presence of a faint non-thermal UV source or point-like radio source (Ho et al. 1995, Maoz et al. 1995, Falcke et al. 1997).

A vigorous effort is going to be made in the coming decade(s) to measure the black hole mass M_{BH} and the accretion rate $\dot{M}$ in the above mentioned AGN subclasses, and in quasars and classical Seyfert 1s. It will then be possible to place all these AGN in the parameter space M_{BH}, $\dot{M}$.

The next step will be to investigate which of the various accretion processes prevail in the different regions of the $M_{BH} - \dot{M}$ plane and in the different luminosity intervals in the AGN Luminosity Function: accretion of individual stars, or of micro clouds; stellar collisions; cooling flows; large continuous flows triggered by bars or mergers; advection.

Figure 1 is a sketch of our current knowledge on M_{BH} and on the ratio

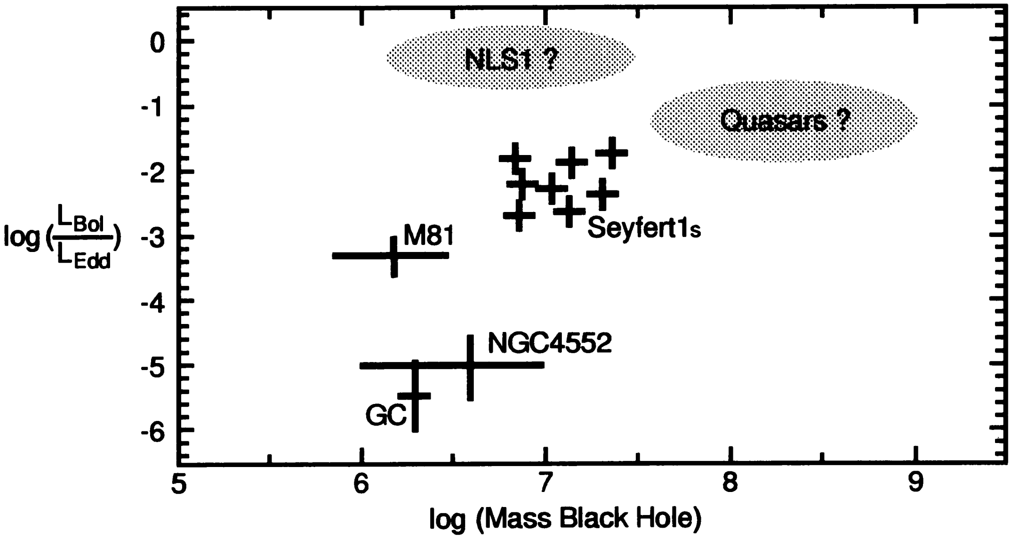

Figure 1. Sketch as of August 1997 summarising our knowledge of how the M_{BH}, L_{Bol}/L_{Edd} parameter space is populated. Note that different accretion processes could prevail in different areas of the diagram.

L_{Bol}/L_{Edd} (rather than $\dot{M}$). The thick crosses represent the general area occupied by Seyfert 1s as determined from measurements (see Ulrich et al. 1997). The references for the three points representing specific AGN are the following: M 81 (Ho and Sargent 1996); the Galactic Center (Mezger 1994, Genzel et al 1997), and NGC 4552 (Renzini et al 1995, and assuming M_{BH} between 10^6 and 10^7 $M_{\odot}$).

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