1156-220 instead of 1256-220). The spectrum of this object, exposed for 30 minutes, clearly shows two strong emission lines identified with C III] λ1909 and Mg II λ2800 at redshift z = 1.306 (Fig. 1).

UM 590 (1334-00) is a 17 magnitude quasar found in an objective prism survey carried out with the 61 cm aperture Curtis Schmidt telescope at the Cerro Tololo InterAmerican Observatory (MacApline et al., 1981), with a suggested redshift z = 2.85. A 10 minute spectrum (Fig. 1) shows three strong emission lines: Lyα, O IV] λ 1302 and C IV λ 1550 from which a redshift of 2.79 is measured.

References

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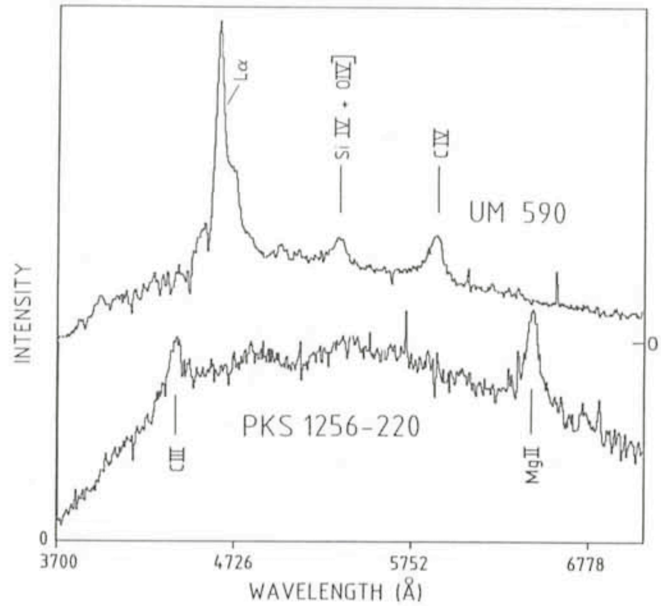

Fig. 1: *The two sky-subtracted, wavelength-calibrated QSO spectra obtained with EFOSC. No flat fielding or spectral response correction has been applied. The plots show rather effectively the good S/N that was achieved in the two observations.* ▶

Study of the Overall Spectrum of the QSO 3C273

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Seyfert galaxies, quasars (QSOs) and possibly BL Lac objects have some basic properties in common. We therefore expect them to be different manifestations of the same basic phenomenon and call them Active Galactic Nuclei (AGN). Provided that our estimates of distances based on redshifts are correct, the AGN are the most luminous objects we know. Their luminosities range from 10^{44} ergs/sec for Seyfert nuclei to some 10^{47} ergs/sec for bright quasars (or 10^{11} to 10^{14} $L_\odot$ where $L_\odot$ is the luminosity of the sun). On the other hand, these objects are variable in most of the spectrum on time scales of years and less, which means that they are smaller than a few light years (light weeks for some objects). How to radiate such a large quantity of energy from such a small volume is one of the most puzzling questions of modern astronomy, and as yet unanswered.

The overall spectrum of AGN is very different from that of stars or galaxies. Instead of peaking strongly at one energy (wavelength) characteristic of a temperature, the AGN emit roughly the same quantity of energy in all decades of frequency between the radio and the γ-ray ends of the electromagnetic spectrum (see Fig. 2 for an example). Another common way for AGN to free energy is by means of one or two sided jets.

In order to generate the photon energy distribution of AGN, it is necessary that several regions with very different physical characteristics are involved in emission processes. Two questions must therefore be answered to understand the overall spectra of AGN: 1. Where does the energy come from (in other words, what is the central engine)? And, 2., what are the physical conditions in the different regions and how are they linked together? Or: what is the structure of the emission regions? This paper deals with a theoretical and an observational approach to the second question.

Most of the present conceptions on AGN involve a massive black hole and an accretion disk (see the proceedings of the conference on X-ray and UV Emission from Active Galactic Nuclei, Max-Planck-Institut für Extraterrestrische Physik, Garching, 1984, for an up-to-date survey). The origin of the radiated energy is thus of gravitational nature and the overall spectrum is explained by the structure of the accretion disk and maybe the presence of a hot corona surrounding it. A different view on this question will be presented in the next section and an observation programme to test it will be described at the end of the paper.

The Wind and Shock Model

In the last two years, M. Camenzind (Institute of Theoretical Physics, University of Zurich) and myself have developed a model to explain the overall structure of the emission spectrum of Active Galactic Nuclei (1). Our effort is aimed at understanding individual objects (say, the QSO 3 C 273) rather than global properties of broad classes of AGN. The model can be adapted to different sources by varying its free parameters.

The object at the very centre of an active nucleus (the engine) need not be defined in detail for our purpose. It may be the inner part of an accretion disk, a rotating super-massive star ($\sim 10^8$ $M_\odot$) or a very dense cluster of stars. The radius of this central engine is expected to be of the order of 100 Schwarzschild radii. It is important to note that these objects are radiation pressure dominated and hence marginally stable. In these conditions, a very strong wind accelerated by radiation pressure or magnetohydrodynamic processes is inevitable. The wind velocity will be a few times the escape velocity (approximately 0.1 c) and its kinetic energy comparable to the radiation luminosity of the central object. (The exact ratio is a free parameter in the model). The density in such winds is such that they are optically thick close to their centre and that a photosphere is defined, hiding the central object from direct observation and emitting strongly in the UV.

The outward pressure of the wind decreases with increasing radius, thus, provided the region is surrounded by a magnetic field B (expected to be of the order of a Gauss and a free parameter in the model), there exists a radius R_s where the

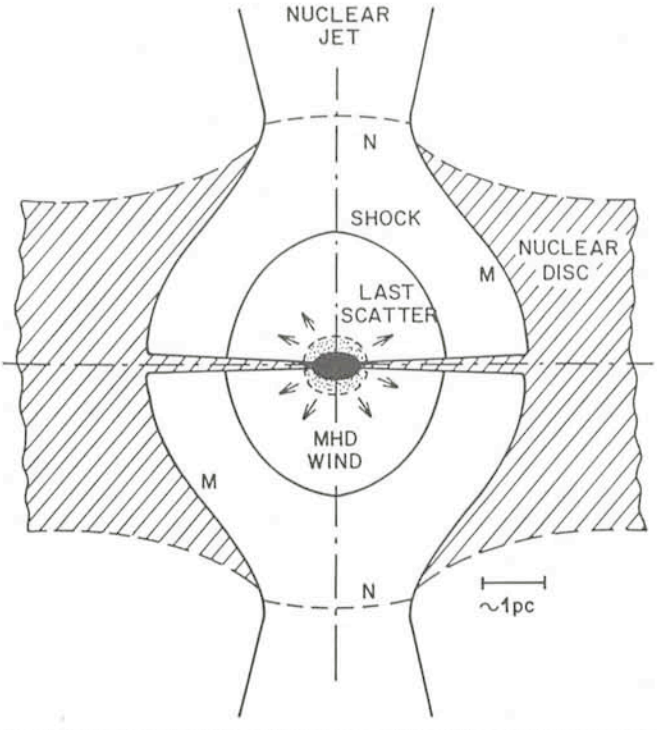

Fig. 1: *Schematic (not to scale) representation of the main elements of the wind and shock model for active galactic nuclei. A suprastellar wind is accelerated from the central source to a few times the escape velocity and slowed down in a shock. The shocked region is the source of the non-thermal radiation and the BLR. Matter escapes in two collimated jets. The whole structure lies at the centre of the nuclear disk of the host galaxy.*

wind is slowed down and its kinetic energy dissipated. This radius is determined by the equality of the magnetic confining pressure and wind pressure; it is of the order of 10^{18} cm for B $\simeq$ 1 G and $\dot{M} \sim 1\ M_\odot$/year ($M_\odot$ is the mass of the sun).

The wind is stopped in a strong shock and its kinetic energy transferred to the shocked matter. This matter is heated to a very high temperature which is limited to some 10^9 K by electron-positron pair production. In addition, electron and positron pairs can be accelerated to highly relativistic energies in the shock, producing a power law energy distribution. Two properties of the hot matter are important here. The first is that the electrons can cool by transferring energy to the UV photons (comptonization), thus producing an X-ray power law spectrum. The second is that a second phase coexists with the hot matter which is cooler and denser ($T \sim 10^4$ K and $n \sim 10^9$ cm^{-3}). The matter in this second phase is ionized by the UV and X-ray radiation and cools by line radiation, forming the broad line region (BLR) of AGNs. The velocity characteristic of the BLR is given by the post shock velocity of approximately $\frac{1}{4}$ of the wind velocity or 0.025 c (7,500 km/s). The relativistic electrons and positrons moving in the magnetic field produce a power law synchrotron radiation in the IR and optical domains of the spectrum. They can also transfer energy to the softer photons by inverse Compton scattering and boost some photons to γ-ray energies.

The different components of the model are shown in Fig. 1 and a semi-quantitative comparison between the overall spectrum of 3C 273, calculated using the ideas presented here, and some observations is given in Fig. 2. Fig. 2 gives the energy radiated in each decade of frequency versus frequency. Region S (synchrotron) is the IR-optical part of the spectrum where the photons are emitted by relativistic electrons in the magnetic field; the UV part of the spectrum is a thermal black body of 26,000 K emitted at the photosphere of the central body; the CUV photons are emitted by thermal comptonization of UV photons and the ICUV and ICX photons are emitted by inverse Compton scattering of the UV and X photons on the highly relativistic electrons and positrons.

Coordinated Observations of 3C 273

The observations used in Fig. 2 had not been performed simultaneously. 3C 273 is known to vary by factors of 2–3 in different spectral domains. Even though these variations are small compared to the flux differences in the different spectral domains (see Fig. 3), it is highly desirable to avoid uncertainties due to different observing epochs. This point will become more important as the calculations grow more detailed. In addition, the only way to observe causal relationships between the different physical components of a model (and hence to test the structure proposed by the model) is to study the correlations between temporal variations in the different spectral domains. For these reasons, it seems indispensable

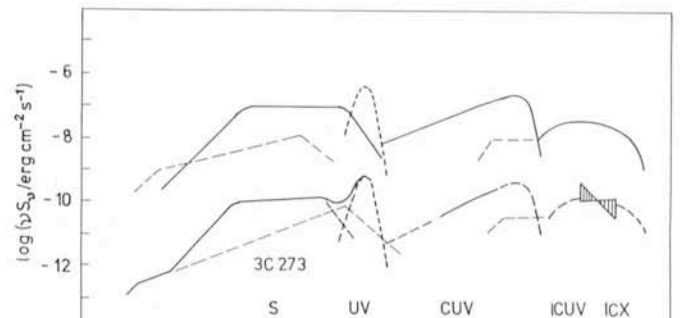

Fig. 2: *Emission spectrum of the AGN as calculated in the wind and shock model (arbitrary scaling). Some observations of the QSO 3C 273 are shown for comparison in the lower part of the graph (solid lines). The figure is from Courvoisier and Camenzind, 1983,* Astrophys. and Space Sc. **93,** *277, where the origin of the observations is quoted.*

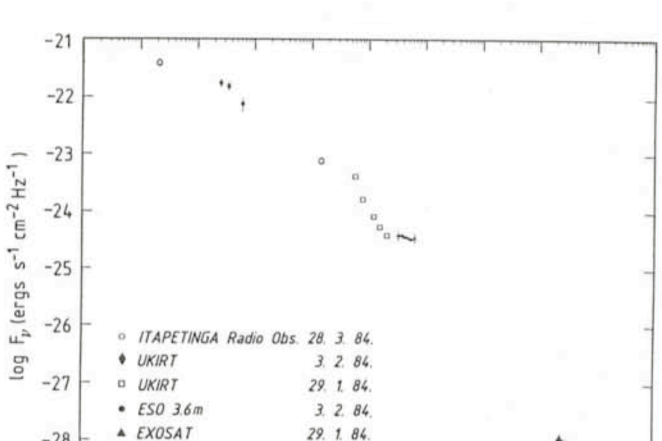

Fig. 3: *The spectrum of 3C 273. Infrared to X-ray data were taken within a week at the beginning of February 1984. Radio observation was taken 2 months later. The cut-off in the IR power law at 10^{14} Hz is clearly seen, so is the thermal excess in the optical spectrum. X-ray data are from the Argon chamber of the EXOSAT ME detector.*

to observe as large a part of the spectrum as possible quasi simultaneously with different instruments. Ideally, the process should be repeated regularly. The difficulties with this type of studies are the concentration of data from many different groups of workers and the necessity to know the absolute calibration of all the instruments involved.

The availability of the European X-ray satellite EXOSAT (2) since May 1983, and presumably until well into 1987, is an excellent opportunity to attempt several observations between the radio and X-ray ends of the spectrum. 3C 273 is an ideal candidate for this study since it is bright in all relevant wavebands. Several observations of 3C 273 have already been performed with EXOSAT (3) and it seemed useful to extend the observations to several other wavelengths.

We now have 2 quasi-simultaneous spectra of 3C 273 covering 8 decades in energy and separated by 5 months. We intend to continue this monitoring during the lifetime of EXOSAT. Two of the instruments on board EXOSAT can be used for these observations: the LE (low energy imaging telescope) and the ME (medium energy experiment). Spectral information using the LE is obtained by making observations through 3 (overlapping) filters between 0.1 and 2 keV. The Argon chamber of the ME gives the spectrum between 1 keV and 10 keV (the only data used in Fig. 3) and the Xenon chamber can be used to extend the spectrum to approximately 30 keV depending on the background during the observation.

A preliminary reduction of the data obtained in February is shown in Fig. 3. The components of the spectrum described above are clearly recognised: The IR-optical synchroton emission described by a power law of index $\alpha = 0.76$ and steepening to $\alpha \simeq 1.6$ at 10^{14} Hz, the thermal component in the optical spectrum (no UV data were available in February), and the comptonized X-ray spectrum of index $\alpha_x = 0.47$.

The data used in the compound spectrum of Fig. 3 are courtesy of D. Molteni, L.C. Botti, E. Scalise (Radio Observation); E.I. Robson, W.K. Gear, P.A.R. Ale (IR photometry); T. Courvoisier and K. Beuermann (Optical Spectrum) and M. Turner, T. Courvoisier, R. Staubert, D. Molteni and J. Trümper (X-ray Spectrum). The spectrum obtained in July includes (in addition to similar observations as in February) an IUE spectrum and a high energy X-ray measurement with which we hope to extend our energy coverage to 150 keV.

The two types of studies mentioned here, theoretical modelling and observations of overall spectrum of an object, give complementary information on the structure of an active galactic nucleus. The observations provide stringent tests and constraints for the proposed model, and the model provides a means of interpreting the measurements in terms of the physics involved in the nucleus. Once our understanding of a few well-studied objects has progressed significantly, it will be possible to use the acquired knowledge together with survey studies to describe the physical structure of active galactic nuclei in general.

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The Sun and α Cen A

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The closest known star apart from the Sun is a very faint object called Proxima Centauri. The next closest star is Alpha Centauri or *Rigil Kentaurus* which forms a binary system having components designated as α Cen A and α Cen B. The component called α Cen A is of particular interest because it strongly resembles the Sun. As a matter of fact, it resembles the Sun to such an extent that it has been called a solar twin. Several researchers have taken a close look at α Cen A using different means in trying to find out exactly what its properties are. Photometry of an object as bright as α Cen A with a cooler component within 18 arcsec of angular distance may suffer from systematic errors. And analysing spectra of α Cen A is hard to do with sufficient accuracy.

The preliminary result reported here is based on a very strict comparison with the Sun. That means that we cannot give very accurate numbers for example for the temperature or chemical abundance of iron for α Cen A but we can report with considerable accuracy how much hotter α Cen A is than the Sun and how much higher its abundance of iron is.

A fortunate circumstance relating to this work is that a spectrum atlas of the Sun as a star, i.e. using light from the whole solar disk, has recently been prepared by Kurucz, Furenlid, Brault, and Testerman using the Fourier Transform Spectrometer at Kitt Peak National Observatory. The atlas (publication planned for the coming year) covers the wavelength range 3000 to 13000 Å. The resolution in the visual part of the spectrum is around 500,000 and the signal-to-noise ratio typically 3,000. This unusually good spectrum provides the reference against which we compare the spectra of α Cen A, obtained at ESO with the CAT and Reticon detector. The ESO spectra are also of excellent quality, having a resolution of 100,000 and signal-to-noise ratio of around 500.

The preliminary analysis carried out so far was done in the following way. The solar spectrum was degraded to a resolution of 80,000, the continuum fitted, and a plot made on a uniform wavelength scale. The spectrum of α Cen A was given exactly the same treatment with particular emphasis on locating the continuum in a consistent way for both Sun and α Cen A. Around 25 absorption lines of iron were then selected and their equivalent widths measured. The lines were carefully chosen so that some of them originated at low energy levels and some at high levels while some of the lines are weak and some strong, and some of them arise from neutral iron and some from once ionized iron. By picking lines in this fashion we can assure high sensitivity to temperature effects, microturbulence, and pressure or surface gravity.

The data analysis made use of stellar model atmosphere programme ATLAS 6, kindly brought to us by its author, Dr. R. Kurucz. In an iterative process we varied temperature, surface gravity, and microturbulence for the solar data until all lines gave the same chemical abundance for iron. The requirement