made with the WSRT in 1975 in order to extend the radio spectra. The 21 cm map is shown in Figure 5; the five Asiago SNR candidates are shown. The SNR 1, 2 and 3 are the objects confirmed in the AAT study.

In 1978, we used the Very Large Array of the National Radio Astronomy Observatory in Socorro, New Mexico, to map SNR 1 and 2 at 6 cm. The goals were to determine the radio sizes with an angular resolution of 1.5 arcsec and to measure the flux densities at 6 cm.

The main results of the radio observations are:

(1) SNR 1, 2 and 3 have non-thermal radio spectra in the range 6 to 49 cm. The spectra are similar to galactic SNR.

(2) The radio positions agree precisely with the optical positions. There is little doubt of the correspondence of the two.

(3) Based on the measured angular sizes at 6 cm, the distance to M33 can be estimated. We assume the surface brightness (flux density/square of the angular size) diameter relationship for our Galaxy holds for M33. The determined distance is 860 ± 200 kpc. Although the error is large, the result is in good agreement with optically determined values.

We have also used the new 21 cm WSRT map to look for radio counterparts of the 20 new SNR candidates found at Palomar. In order to increase the reliability of the identifications, the optical positions have been measured to a precision of about 1 arcsec. Only two new positive identifications of weak radio sources and optical SNR can be made (two more are possible). It does appear that of the roughly 100 discrete radio sources in the WSRT map of M33 only very few can be unambiguously identified with optical SNR. The remainder of the radio sources are HII regions. Why is the rate of detections so low? This is simply a matter of sensitivity. Although we can detect a point source of 0.4 milli-Jansky throughout the disk of M33, this corresponds to a galactic SNR of ~ 200 Jy at a distance of 1 kpc. There are very few galactic SNR of such intensity. Thus with presently available radio techniques we can only detect the strongest SNR in M33.

4. How Complete is the SNR Sample in M 33?

From the above discussion, it is fair to remark that in the case of M33 the optical method of identification has still an edge with respect to the radio surveys. This is also true for the 0.5-4.5 keV imaging survey of M33 obtained with the Einstein Observatory. Only nine sources were detected in the galaxy field and no coincidences were found with the optical candidates.

This is not unexpected because, at the detection limit of the instrument, a source equivalent to the Cygnus Loop at the distance of M33 would not have been detected and very young remnants (possibly one or two) with strong X-ray emission could not have yet developed a significant optical counterpart.

There are two main reasons of interest in the SNR counts in M33. We can use them to check the SN frequency in a Sc galaxy (this time looking at all SN exploded in a single galaxy during the last few thousand years instead of looking at several galaxies over a few years interval). Second, we can pinpoint the location of the SN explosions and try to associate them with the stellar populations.

At present, we have no way to say whether an observed remnant is due to a type I or type II supernova. At this point one may wonder about the completeness of the sample of 20 SNR selected on the basis of the [SII]/Hα criterion.

Two confusion effects may play a role. First there is the problem of the large shells of ionized gas which originate as a consequence of supersonic stellar winds. It has been suggested by Lasker that the large loops seen in the Large Magellanic Cloud may have this origin (1977, *Ap.J.* **212**, 390) and by mimicking the line intensities and radio emission of SNR, contaminate their sample at large diameters. Several circular HII regions are present in M33 but their Hα/[SII] ratios do not appear as low as in the SNR candidates neither do we observe an excess of SNR with large diameters.

A second effect which will make our sample incomplete is the presence in the galaxy of SNR which do not obey the [SII]/Hα criterion either by the absence of [SII] lines, like the faint filaments in Tycho and the stationary knots in Cas A, or by being oxygen-rich with little H, N and S to give rise to the red emission lines (like G292.0+1.8 as reported by Goss et al. *M.N.R.A.S.* **188**, 357, 1979). These characteristics however are peculiar to a few, probably young SNR and should have little effect on the global statistics.

Observations of Radio Galaxies

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It appears that only ellipticals become powerful radio galaxies. We believe this to be due to the depth of the gravitational potential well and the characteristic paucity of interstellar material in these galaxies. Aside from the particular interest of the nuclear activity associated with the radio galaxy phenomenon, these objects may, in two rather distinct ways, give us very useful information about the intergalactic medium in a range of different environments.

Firstly, there is growing evidence that the onset of nuclear activity and the subsequent generation of a powerful extended radio source may be triggered by a sudden increase in the gas content of the nuclear environment of an elliptical. This may be brought about by a close gravitational encounter with a neighbouring gas rich galaxy or even, perhaps, by the accretion of primordial intergalactic gas.

Secondly, once the extended radio source has formed, characteristically with a double-lobed morphology, its detailed properties can tell us something about the intergalactic medium with which it is interacting. The high-resolution, high-sensitivity radio maps now being made with the aperture-synthesis telescope show a very clear connection between the galactic nuclei and these sometimes

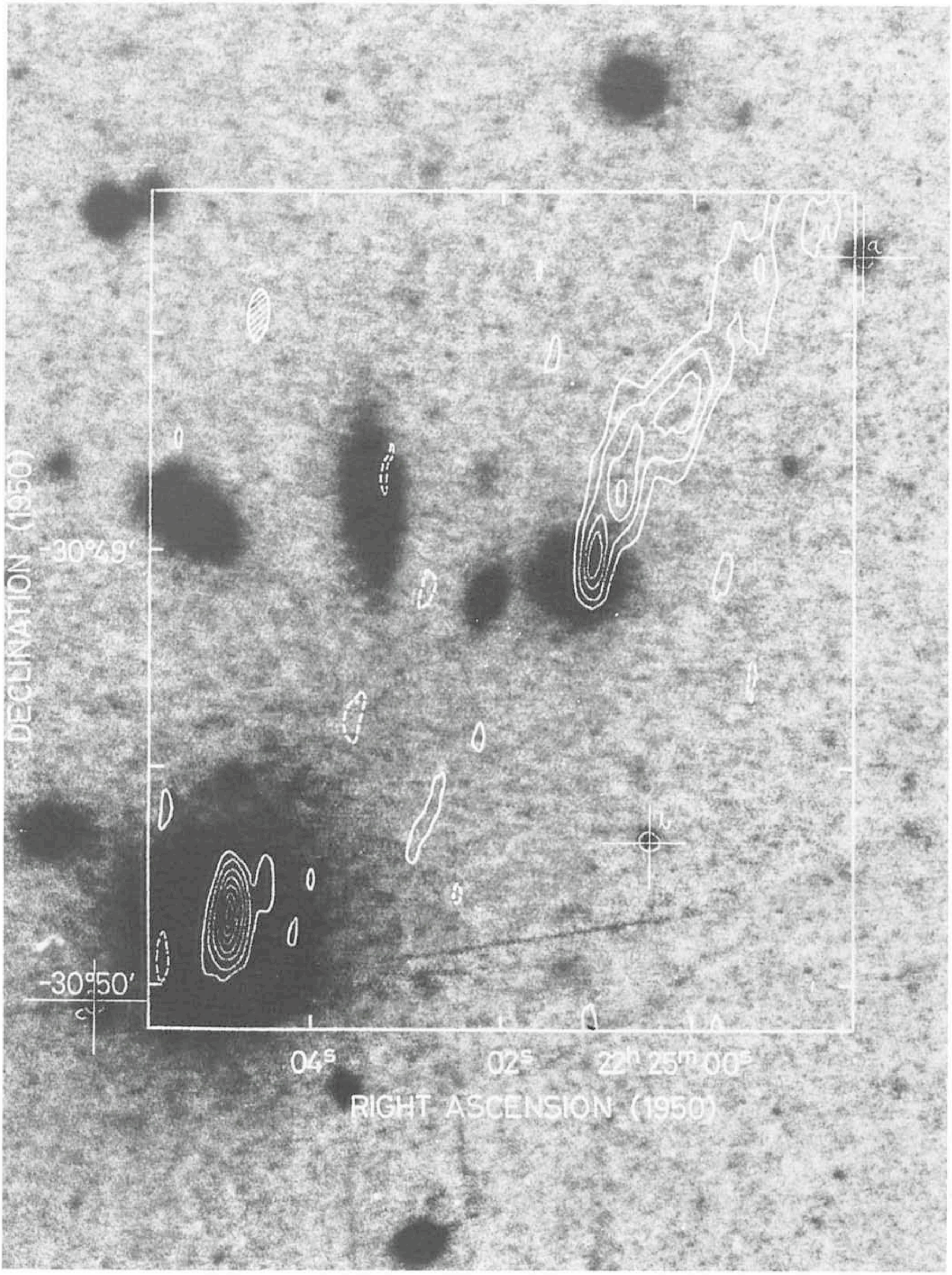

Fig. 1: *A 5 GHz VLA map of the southern radio source PKS 2225 – 308 overlaid on a Schmidt photograph of a cluster of galaxies. The VLA shows the radio source to be double but not in the classical sense. Each of the two sources is associated with a different galaxy, one being a point and one a head-tail source.*

very extended (several Mpc) outer regions. The sequence of aligned features and jets continue right down to the milliarsecond scale revealed using VLBI techniques.

A desire to study the interaction between a galaxy and its surroundings and, in particular, the role of the radio galaxy phenomenon in the evolution of ellipticals, has prompted a rather ambitious multi-wavelength survey of radio galaxies.

A collaboration consisting of John Danziger and Peter Shaver from ESO, Ron Ekers and Miller Goss from the University of Groningen, David Malin from the Anglo-Australian Observatory and Jasper Wall and myself from the Royal Greenwich Observatory has selected a sample of about a hundred galaxies from the Parkes 11 cm radio survey. Because of our interest in the optical morphology of the galaxies, our sample has been chosen to be within the area of the southern IIIa-J sky survey, that is with $\delta < -17^{\circ}$. So that we could study the radio morphology with the Very Large Array (VLA) in New Mexico, the southern declination had to be limited to -40°. The observational material so fast accumulated includes: 5 GHz radio maps for all sources from the VLA (see Fig. 1), optical spectrophotometry for all sources from the ESO 3.6 m, the Anglo-Australian Telescope (AAT) and the Las Campanas 2.5 m, a large amount of new radio data from Molonglo, Culgoora, Fleurs and Parkes in Australia and access to many original plates from the UK Schmidt Telescope together with some short-exposure plates from the AAT. In addition, about a third of the galaxies have so far been observed in the infrared (H, K and L bands) by Pierro Salinari and Alan Morewood with the ESO 1 m and 3.6 m telescopes and the UK Infrared Telescope (UKIRT) in Hawaii. Not to be left out, the Danish 1.5 m telescope on La Silla has been taking some fine electronographs using the McMullan Camera. At least two of the galaxies have been observed with the IUE satellite and several more are scheduled for the Einstein satellite.

The sample has been chosen to be complete down to the radio flux density limit of the Parkes survey for all galaxies brighter than 17th magnitude. The observations are obviously yielding a wealth of statistical information but apart from that there are, of course, some objects of outstanding individual interest. It is to one of these that I wish to devote the rest of this article.

There have now been three spectroscopic observing runs on the 3.6 m telescope using the University College London Image Photon Counting System (IPCS). The first of these has already been described in the *Messenger* by Danziger and de Jonge (*Messenger* **15**, December 1978, p. 19). One of the observing programmes was to do spatially resolved spectroscopy of radio galaxies using a long spectrograph slit and the large digital memory now available with the IPCS.

It has long been known that some radio galaxies exhibit strong, high-excitation emission-line spectra not unlike those seen in the class 2 Seyfert galaxies. Unlike the spiral Seyferts known, however, we noticed that in the radio galaxies these high-excitation lines could come from a region of very large spatial extent, in one case over 100 kpc. One of the most spectacular of these objects, PKS 2158 – 380, had already been observed to have extended emission lines by Mike Disney a number of years ago at Mt. Stromlo. It has now become the subject of a detailed observational study using a range of different techniques and involving a corresponding range of investigators (R. A. E. Fosbury, A. Boksenberg, M. A. J. Snijders, I. J. Danziger, M. J. Disney, W. M. Goss, M. V. Penston, W. Wamsteker, K. Wellington and A. S. Wilson, to be submitted to *M.N.R.A.S.*).

Why should this phenomenon occur in some elliptical radio galaxies and not apparently in the spiral Seyferts? Does it stem from the differences in the nature and distribution of the interstellar material between these two types of galaxies or do they just have different ionization mechanisms operating? Perhaps more importantly, do the extended emission lines tell us anything about the origin of the radio galaxy phenomenon?

Fig. 2 shows a low-resolution, two-dimensional spectrum of P 2158 – 380 taken with the IPCS on La Silla. One thing it tells us immediately is that we are not seeing just a galaxy with an extended distribution of ordinary H II regions, photoionized by young hot stars. The level of excitation is far too high; even the He II λ 4686 line is strong over 10 kpc from the nucleus.

It seemed possible that the gas was being ionized by an intense source of hard ultraviolet radiation which, if it existed, was presumably located at the nucleus. Indeed, the optical continuum consists only of integrated starlight but, then, if the UV spectrum were hard enough, it could easily provide enough ionizing photons without significantly contaminating the optical spectrum. It would be difficult though for it to hide from the IUE satellite.

Objects as faint as this (15.3 mag. in the U band) are quite hard work for the 18 inch telescope of IUE. Nevertheless, in the short-wavelength region we could see that there is a point source of ultraviolet radiation which does indeed radiate enough flux to ionize all the gas we see emitting line radiation further out in the galaxy. It can only

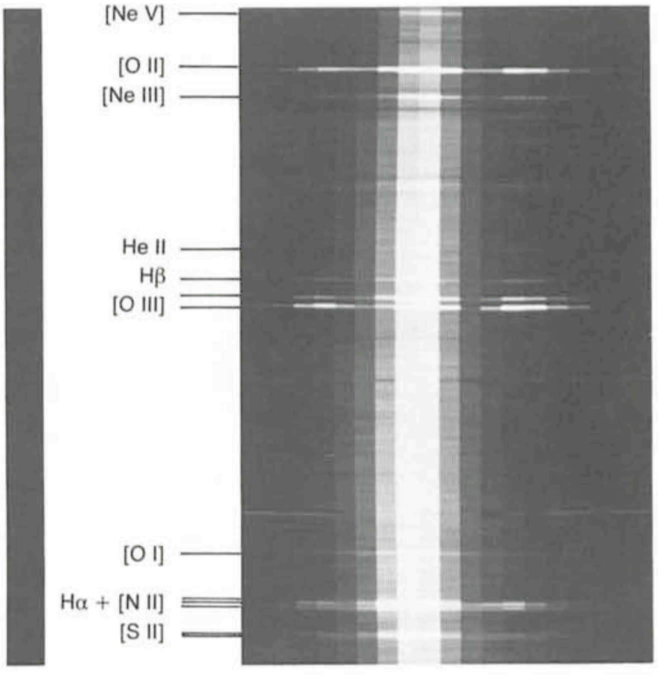

Fig. 2: *A two-dimensional spectrum of the galaxy associated with PKS 2158 – 380 obtained with the IPCS on the 3.6 m telescope on La Silla. This covers the whole optical spectrum from about 3400 – 7000 Å and each horizontal strip covers about 1.6 kpc at the galaxy. This spectrum photographed from a TV-monitor in Geneva, is fully calibrated. That means that the intensity in the picture represents the flux per unit wavelength from the galaxy. The continuum in the centre comes from the stars in the galaxy and several of the stellar absorption lines can be seen. The emission lines come from a region over 30 kpc in extent and the gas is in a high state of ionization throughout.*

do it, however, if a rather special condition on the distribution of the gas is fulfilled. Put simply, this is that a large fraction of the Lyman continuum radiation emitted by the nucleus must be intercepted by gas in the galaxy; but this cannot all happen close to the nucleus; a good fraction of it must be absorbed kiloparsecs away where we still see strong line radiation. This immediately rules out a simple geometry like a thin planar disk of gas which, to the nucleus, would cover only a very small fraction of the sky. It is possible to avoid this problem by assuming that the nucleus does not radiate its UV flux in an isotropic fashion and indeed, it may be that, given the high degree of anisotropy exhibited by the radio emitting material, the higher frequency radiation is beamed in some way.

A way out of this dilemma may be sought by appealing to observations of the dynamical state of the material in the galaxy, both stars and gas, and also, perhaps, by drawing analogies with objects closer to home (PKS 2158 – 380 is at 200 Mpc with $H_o = 50$ km s^{-1} Mpc). High spectro/spatial resolution observations of the [OIII] lines obtained with the IPCS on the AAT reveal the motion of the ionized gas in some detail. The velocity profile along the major axis of the emission line distribution does look rather like a normal galaxy rotation curve, but there are some peculiarities.

The change from positive to negative velocities happens at very small radii; within ± 2 kpc of the nucleus. Also, the emission line profile is broad at all radii with wings extending to over 300 km s^{-1} towards higher $|\Delta v|$. In contrast, the stars do not rotate at all about this axis ($<$ 15 km s^{-1} kpc^{-1}), so their motions are clearly quite decoupled from that of the gas. This lack of coupling strongly suggests that the gas is not native to the elliptical galaxy but has somehow recently been acquired. If the gas has been accreted, either from another galaxy in the small group of which PKS 2158 – 380 is a member, or directly from the intergalactic medium, then it is natural to expect any initially formed gaseous disk to be subject to perturbing forces. These could come either from the nonsperical symmetry of the ellipticals' gravitational potential or simply from the proximity of another galaxy. We propose that there is a rotating gaseous disk in PKS 2158 – 380 but that this disk has been severely warped by some such perturbation. The warp could look something like the photographs of a model shown in Fig. 3 which in turn shows a strong resemblance to deep photographs of the dust lane in the famous radio galaxy Centaurus A (NGC 5128). It can be seen in this picture that radiation from the nucleus can easily shine out to large distances before being absorbed by gas. Also, a good fraction of the nuclear sky can be covered by gas (about 40% in this illustration). Without going into detail, it is clear that the kinematical state of such a structure, deduced from slit spectroscopy, may appear quite complex; we believe that it is possible to interpret our "rotation curve" in this context.

While our interpretation of the observations may not be unique, it does perhaps give some clues about another radio galaxy puzzle. That is the question of the alignment of the radio axis (the line joining the components of the double) with the rotation axis of the galaxy.

Firstly there is the problem of defining this rotation axis when we know that the stars and gas can be decoupled.

Secondly, if we choose the gas as being the relevant component (after all the gas feeds the black hole which makes the radio source), we have the problem of defining the rotation axis of a highly non-planar disk. Our spectroscopic observations will indicate a rotation axis appropriate to the gas at some radius where the emission appears strongest and may tell us nothing about the conditions close to the nucleus. We can only say that in the two objects with extended emission lines which we have studied in detail, this and PKS 0349 – 27, there is no alignment between the radio and the apparent gaseous rotation axis. Although observations of other radio galaxies suggest that such an alignment does usually exist, this topic demands many more observations.

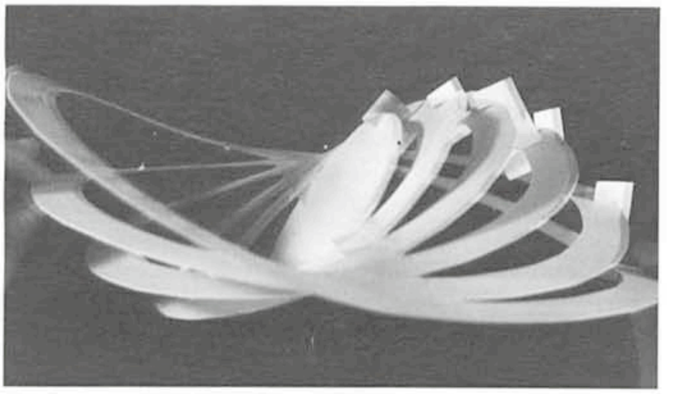

Fig. 3: *A cardboard model of a warped disk which we have used to represent the distribution of gas in PKS 2158 – 380. An important feature of this model is that, viewed from the centre (nucleus), a large fraction of the sky can be covered with gas.*

Our investigations of this galaxy have shown it to be an example of a situation where the dynamical state of the gas must be changing on a time scale which is very short compared to the evolutionary lifetime of the whole system. We believe that this rapid evolution of the gas content may be the cause of the nuclear activity and the extended radio source.

NEWS AND NOTES

The "Centre de Données Stellaires" at Strasbourg

The purpose of this note is to describe the assistance the "Centre de Données Stellaires" (CDS) can provide for either the preparation of an observing programme or for a discussion of results.

Let us state briefly that the "Centre de Données Stellaires" is an institution founded in 1972 by the French astronomical community with the aim of collecting all available stellar data in machine-readable form, in order to facilitate their use. The collection and analysis of the data is made by specialists in each field. Besides the staff of the CDS, several Institutes, namely:

Observatoire de Paris, Meudon
Observatoire de Marseille
Observatoire de Genève et Institut d'Astronomie de Lausanne
Rechen-Institut, Heidelberg
Zentralinstitut für Astrophysik, Potsdam

collaborate closely with the CDS and provide the coverage of certain areas. Furthermore, data exchanges exist with other institutes, like the:

Goddard Space Flight Center, NASA
Astronomical Council of the USSR Academy of Sciences
Computer Center, Kanazawa, Japan.