3. . . . But a Surprising Object

Despite the fact that PKS 1610–771 is not a new gravitationally lensed quasar, its spectrum yields a surprise. The spectrum shows a curved continuum breaking at 7600 Å (2800 Å rest frame) (Fig. 2). In order to be sure that this unusual shape was not due to atmospheric refraction, we re-observed the quasar in May 1995 with the slit carefully oriented along the parallactic angle. The spectra of several spectrophotometric standard stars were obtained under similar conditions and used to check the accuracy of the flux calibration (see for more details Courbin et al., 1996). The results obtained confirmed our previous observations indicating that the weird spectrum shape is not due to atmospheric refraction.

Only very few quasars are known to have spectra similar to PKS 1610–771. These unusual spectra lead up to several interpretations out of which it is always difficult to draw a definite conclusion (e.g. Turnshek et al., 1994). One of the plausible scenarios which might play a role in the formation of such continuum is related to internal extinction by dust, which could affect many quasar spectra (Webster et al., 1995).

4. Internal Dust Extinction?

The reddening hypothesis was tested by performing a reddening correction of the flux-calibrated spectrum, using an SMC-like extinction law (Prévot et al., 1984) and assuming the dust at the redshift of the quasar. Figure 2 displays the result of this de-reddening, i.e., a more usual quasar spectrum. However, this certainly does not prove that reddening is responsible for the convex shape of PKS 1610–771's spectrum, but only that it is compatible with it.

In addition, we noticed that the fuzzy elongations north and south (A and D in Fig. 1) of the QSO are oriented perpendicular to the quasar polarisation angle (Impey & Tapia, 1988, 1990), as usually observed in high-redshift radio galaxies and suggesting that both objects are physically related to the quasar. This could suggest that PKS 1610–771 is a radio-loud quasar highly reddened by its host galaxy, but not completely hidden, its polarisation being due to diffusion by dust rather than synchrotron emission. In the framework of the AGN unification scheme (e.g. Urry & Padovani, 1995, Antonucci, 1993), PKS 1610–771 could be intermediate between quasars and radio galaxies.

The complete version of this study is published in Courbin et al. (1996). Surely, this scenario has to be checked in more detail on the basis of future observations, but we believe that PKS 1610–771 is a very interesting quasar to study in the context of AGN unification scheme.

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Two Planetary Nebulae Discovered in the Sagittarius Dwarf Galaxy

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There are currently nine dwarf spheroidal galaxies known in the near neighbourhood of the Galaxy. These small galactic systems are many times more massive than globular clusters and are gravitationally bound to the Milky Way Galaxy. The latest to be discovered was that in Sagittarius (Ibata et al., 1994, 1995), its late discovery attributable to its proximity to the Galactic Centre. It is situated at a distance of 25 kpc (Galactocentric distance 16 kpc) and is interacting with the Galaxy; with an estimated mass of $\geq 10^7$ $M_\odot$ it is perhaps the largest such local dwarf spheroidal. It contains several globular clusters, among them M 54, which may constitute its centre (Ibata et al., 1995). Until very recently the only dwarf spheroidal known to contain a planetary nebula (PN) was Fornax (distance ~160kpc), discovered by Danziger et al. (1978) from on- and off-band [O III] imaging.

As part of a programme to study the kinematic properties of Galactic Centre PN, emission-line radial velocities of some 50 PN were obtained with the ESO 1.4-m Coudé Auxiliary telescope and the Coudé Echelle Spectrograph and short camera (spectral resolution 6kms $^{-1}$). Subsequent to the observations it was realised that several objects in the extensive objective prism surveys of PN in the Galactic Centre region were in fact in the vicinity of the Sagittarius dwarf galaxy. Comparison of the radial velocity of these PN with that of the Sagittarius dwarf (+140 kms $^{-1}$ with velocity dispersion 10 kms $^{-1}$) showed that two objects, He 2-436 (004.8–22.7) and

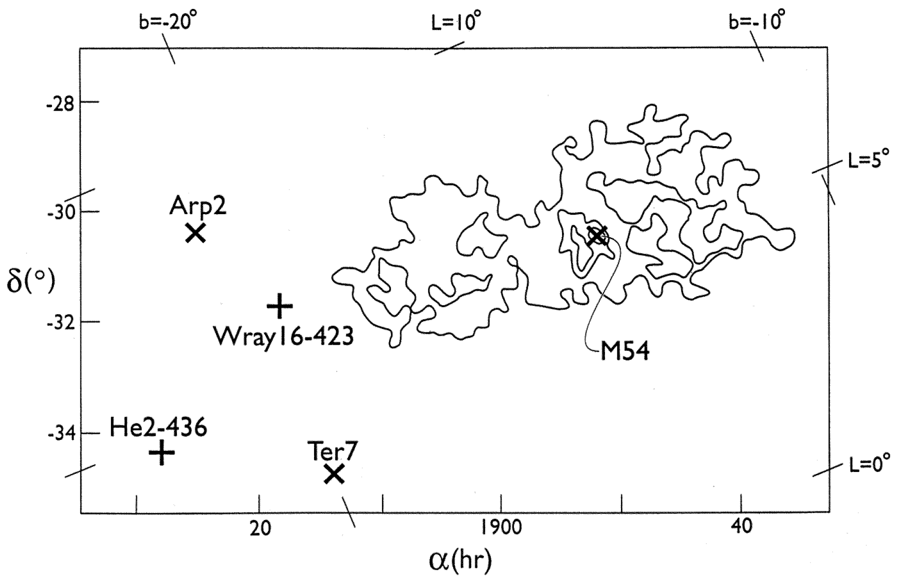

Figure 1: Sketch of the Sagittarius dwarf galaxy and the position of the two PN (pluses). The positions of three globular clusters are also shown (crosses). B1950 equatorial and Galactic coordinates are shown.

Wray 16-423 (006.8–19.8) were very probable members of this galaxy (Zijlstra & Walsh, 1996). Another PN, Hb 8, also lies in the direction of the Sagittarius dwarf galaxy, but has a very different velocity and can therefore be discounted as a member. The position of the two PN now 'discovered' in the Sagittarius dwarf galaxy are shown against a sketch of the galaxy in Figure 1. The two PN are situated some 5° from the core in the direction of the tidal tail found by Mateo et al. (1996). The radial velocity hardly changes from the core south-eastwards (Ibata et al., 1995); the radial velocities of the two PN are in good agreement with that expected for the dwarf galaxy.

In addition, there are two other PN which are possible members of the Sagittarius spheroidal: one, PRMG 1, has no measured radial velocity whilst the other, M 3-33, has a larger positive velocity, suggesting it is not a likely member. Table 1 summarises the properties of these PN. The expansion velocities of both He 2-436 and Wray 16-423 were measured from the full width at half maximum of the [OIII]5007Å line (the lines were not resolved into two components as expected for small or unresolved nebulae) as 13 and 15 kms $^{-1}$ respectively. These expansion velocities are lower than the average PN expansion velocity of ~20 km s^{-1}, but not exceptional.

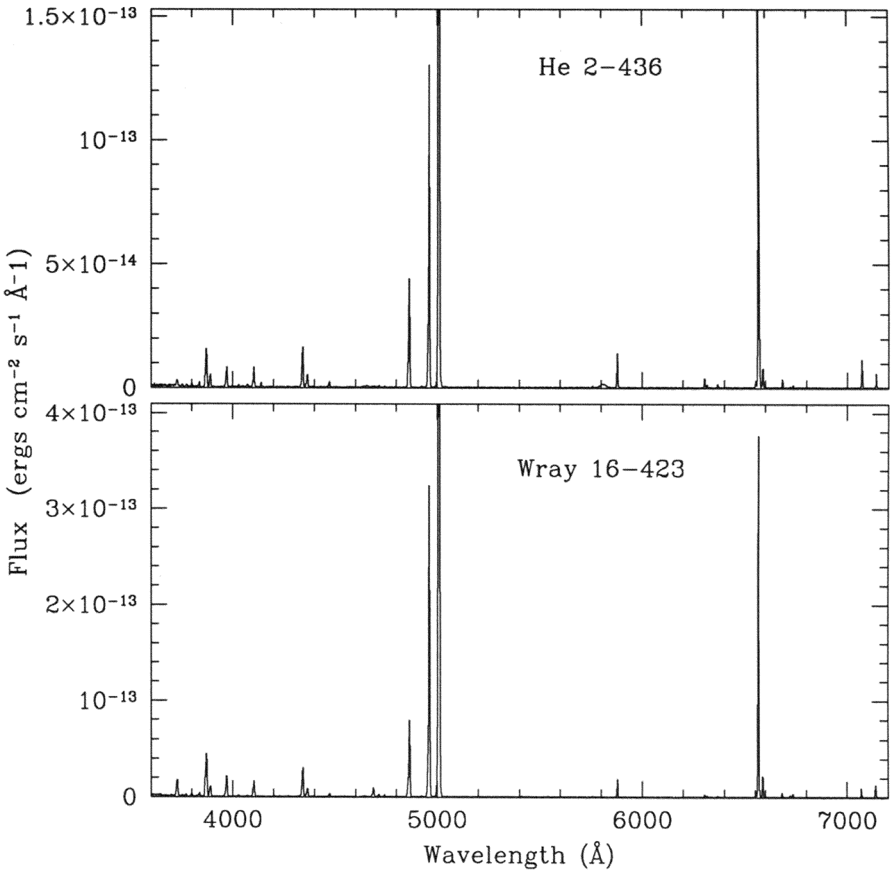

Figure 2: ESO 1.5-m observed spectra of the two PN in the Sagittarius dwarf galaxy.

Further Observations

Following the discovery of the two PN, low-dispersion spectra were obtained during a short allocation of ESO Director's Discretionary Time on the NTT and during scheduled time on the ESO 1.5-m. EMMI with a long slit and grism 2 (resolution 9Å) were used to obtain spectra of both He 2-436 and Wray 16-423 in May 1996 with a wavelength coverage 4000 to 8200Å. Images were also obtained with EMMI in RILD mode using [O III] and Hα+[N II] filters. Further spectra for the important wavelength region below 4000Å and for wide-slit spectrophotometry were obtained on the ESO 1.5-m with the Boller & Chivens spectrograph and a coated Loral CCD (ESO # 39) in June 1996. Full details of the observations and analysis will appear in a forthcoming paper (Walsh et al., 1996). Figure 2 shows the low-dispersion spectra of both PN from the 1.5-m data. It is noteworthy that He 2-436 has a strong broad (stellar) C IV feature at 5807Å indicating a WC-type central star. Wray 16-423 has a very weak stellar feature at C IV. From the [O II], [O III], [N II], [S II], [Ar IV] and [Cl IV] diagnostic line ratios, the characteristic values of T_e and N_e were determined and the abundances of the light elements derived. He 2-436 is a high-density nebula with electron density ~10^5 cm^{-3}, whilst Wray 16-423 has densities typical of many PN at ~5000 cm^{-3}. Both have hot stars as measured from their Zanstra temperatures, but the central star of Wray 16-423 is the hotter and shows He II 4686Å in emission.

The seeing at the time of the NTT observations was not good (measured 1.4″ FWHM). Both PN appear to be unresolved on the raw images. Using stars in the frame, the PN images were restored using the accelerated Richardson-Lucy algorithm. He 2-436 was not resolved but Wray 16-423 showed an elliptical image, with major axis ~ 1.0″. For a distance of 25 kpc, the major axis diameter is 0.13 pc – typical of the size of PN with known distances (e.g. in the Magellanic Clouds – Dopita & Meatheringham, 1991).

TABLE 1. Planetary nebulae in the direction of the Sagittarius Dwarf Galaxy

Name	Designation	RA (J2000)	Dec (J2000)	V_{Hel} (km s^{-1})	Membership
He 2-436	004.8–22.7	19 32 07.3	–34 12 33	+132.9	Probable
Wray 16-423	006.8–19.8	19 22 10.6	–31 30 40	+133.1	Probable
M 3-33	009.6–10.6	18 48 12.0	–25 28 50	+180	Possible
PRMG 1	006.0–41.9	21 05 53.5	–37 08 17		Possible
Hb 8	003.8–17.1	19 05 36.4	–33 1139	–172	Non-member

Discussion

The sample of PN in dwarf spheroidal galaxies has increased by a factor 3 following the discovery of these two PN in the Sagittarius dwarf! This provides a very useful sample of PN in unique low-Metallicity environments and at known distances (derived from e.g. main-sequence fitting). Although many Galactic PN are closer, their distances are difficult to determine. The mean number of PN per solar mass in the LMC, SMC, Galactic disk and bulge (correcting for large number unseen) is about 3×10^{-7} PN $M_\odot^{-1}$. The corresponding value for Fornax is significantly less (a few times 10^{-8} PN $M_\odot^{-1}$) but is similar to that for Galactic globular clusters (based on 3 PN in 133 globulars – Jacoby et al., 1996). Taking the value for Fornax as indicative of the value for the dwarf spheroidal a mass of ~4×10^7 $M_\odot$ for the Sagittarius dwarf is suggested, based on 2 PN. There may be more PN in the Sagittarius dwarf (and in Fornax); deep

[O III] imaging surveys would be useful.

Whilst there are differences between the abundances of the two Sagittarius PN – He 2-436 has a low N abundance – the values generally bracket the abundances for the Fornax PN. The O abundances of He 2-436 and Wray 16-423 differ by only 0.08 dex and the mean of both is 12+Log(O/H)=8.35. The value for the Fornax PN is 8.5 (Danziger et al., 1978). Whilst the O/H abundances of these three PN are lower (by ~0.4 dex) than the average for Galactic PN, they are not as low as that of Compact Blue Galaxies ([O/H]~8.1, e.g. Pagel & Edmunds, 1981), indicating that the PN belong to later generations of star formation. The PN can therefore be regarded as arising in an intermediate-age population and provide a unique diagnostic of the abundances of the light elements, which are difficult to determine from stellar spectra. Mateo et al., (1995) derived an Fe/H abundance of 8% compared to solar for the Sagittarius dwarf, suggesting that [O/Fe] (log O/Fe) is +0.6. Incidentally, the errors on the oxygen abundance are much lower than the errors on the Fe abundance, the latter measured from the integrated stellar population. The [O/Fe] value in the Sagittarius dwarf is higher than for the Galaxy and the Magellanic Clouds (+0.45 and –0.3 respectively, Richer & McCall, 1995), consistent with the galactic evolution models of Matteucci & Brocato (1990).

Although only three planetary nebulae have so far been confirmed in dwarf spheroidal galaxies, they clearly have a pivotal role to play in understanding the star-formation history in these dwarf galaxy systems.

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The Distribution of Ionised Gas in Early-Type Galaxies

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1. Introduction

The presence of significant amounts of interstellar matter (ISM) in early-type galaxies has been recognised only in recent years (see Macchetto *et al.,* 1996 and references therein). The ISM appears to be more complex than in spiral galaxies. Several components have been identified so far: hot (10^7 K) X-ray gas (typical mass range 10^8–10^{10} $M_\odot$), warm (10^4 K) ionized gas (10^2–10^4 $M_\odot$) and cold (< 100 K) atomic and molecular gas (10^6–10^8 $M_\odot$). The amount of X-ray gas is directly related to the optical luminosity of the galaxy (White & Sarazin, 1991) as expected in a cooling-flow picture *(e.g.* Thomas *et al.,* 1986). The HI content (Knapp *et al.,* 1985), dust content (Forbes, 1991) and CO content (Lees *et al.,* 1991) are found to be unrelated to the stellar luminosity in contrast to what is observed in spiral galaxies. It seems therefore that the hot ISM is a bulge-related phenomenon and the cold component is disk-related, with little interaction between the two. Recent studies revealed that the presence of dust and gas in early-type galaxies is the rule rather than the exception (Bregman *et al.,* 1992).

There are two main sources for the observed non-stellar material: either it is coeval with the stars, resulting from stellar mass loss or it is accreted from outside in a second event in the galaxy history. Faber & Gallagher (1976) investigated how much gas may be produced by stellar evolutionary processes. Assuming a stellar mass-loss rate of 0.015 $M_\odot$/ year, 10^9–10^{10} $M_\odot$ of gas can be accumulated over a Hubble time for a typical elliptical galaxy. In the accretion sce-

TABLE 1: Object list.

Object	RSA Type	RC3 Type	B_T	cz [km/s]	
NGC 484		SA0$^-$	13.1	5200	imaging
NGC 745		S0$^+$pec	14.0	5953	imaging
NGC 1395	E2	E2	10.5	1699	imaging
NGC 1453	E0	E2–3	12.6	3933	imaging & spectroscopy
ESO 118-G34		S0^{0}pec	13.5	1171	imaging
NGC 1947	$S0_3(0)$pec	S0$^-$ pec	11.6	1157	imaging
NGC 2974	E4	E4	11.9	2006	imaging & spectroscopy
NGC 3962	E1	E1	11.6	1818	imaging & spectroscopy
NGC 4636	E0/$S0_1(6)$	E0-1	10.4	927	imaging & spectroscopy
NGC 5846	$S0_1(0)$	E0-1	11.0	1710	imaging & spectroscopy
NGC 6868	E3/$S0_{2/3}(3)$	E2	11.7	2858	imaging & spectroscopy
ESO 234-G21		SA0^{0}pec	13.9	5430	imaging
NGC 7097	E4	E5	12.6	2539	imaging & spectroscopy
NGC 7302	$S0_1(4)$	SA(s)0$^-$	13.2	2586	imaging
IC 1459	E4	E	11.0	1691	imaging