Evrard et al. (1994) using hierarchical clustering scenarios indicate that rotating disks with radii of several tens of kiloparsecs should be common around forming galaxies at high redshift.

6. The VLT and the Next Decade

Because of their unique diagnostic abilities, high-redshift radio galaxies are among the most important targets both for the HST and the next generation of large optical-IR telescopes, including the VLT. The VLT should allow the enigmatic outer fainter regions of the galaxies to be mapped and the spatial extensions in some of the weaker emission lines to be measured, thereby providing new diagnostics on the state of the gas.

Here we have concentrated on discussing the gaseous properties of high-redshift galaxies. Studies of stars, dust and synchrotron emission are of course also essential if the history of the galaxy formation is to be pieced together. High spatial resolution images and spectra will measure spectral energy distributions and polarisations for the nuclear regions and continuum clumps, while the kinematics and morphological distribution of the gaseous clumps should provide clues to whether and how the observable gas is being converted into stars.

Not only are distant radio galaxies interesting in their own right as laboratories for studying galaxy formation, but their environments are particularly intriguing regions of the Universe to examine in detail. Such topics are outside the scope of the present article. However, we remark that since low-redshift radio-loud objects tend to be in rich clusters of galaxies, the surroundings of high-redshift radio-loud objects are among the most fruitful places to seek the most distant clusters.

We expect that such studies will provide important new insights into the evolution of galaxies and clusters and that the VLT will play a major role in this exciting work.

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Proper Motions of Galaxies – the Reference Frame

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Introduction

CCD astrometry offers the possibility of measuring proper motions for the nearest galaxies, either from the ground or using HST, in only 5–10 years. An inertial reference frame, however, is needed against which to measure these motions. We have therefore been using the La Silla telescopes to seek QSOs behind several of the nearest satellite galaxies of the Milky Way, using a variety of techniques.

The Prospects for Proper Motions

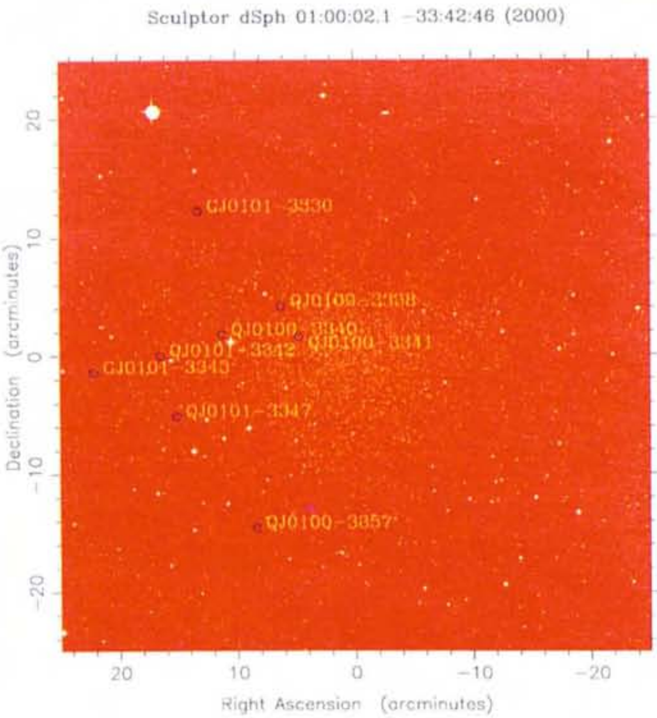
In a previous Report, Tinney (1993) discussed some of the features which make CCDs almost ideal detectors for small-angle, relative astrometry at extremely high precisions (i.e., 110 mas). In particular, it was suggested that an astrometric programme targeted at the nearest galaxies could be fruitful.

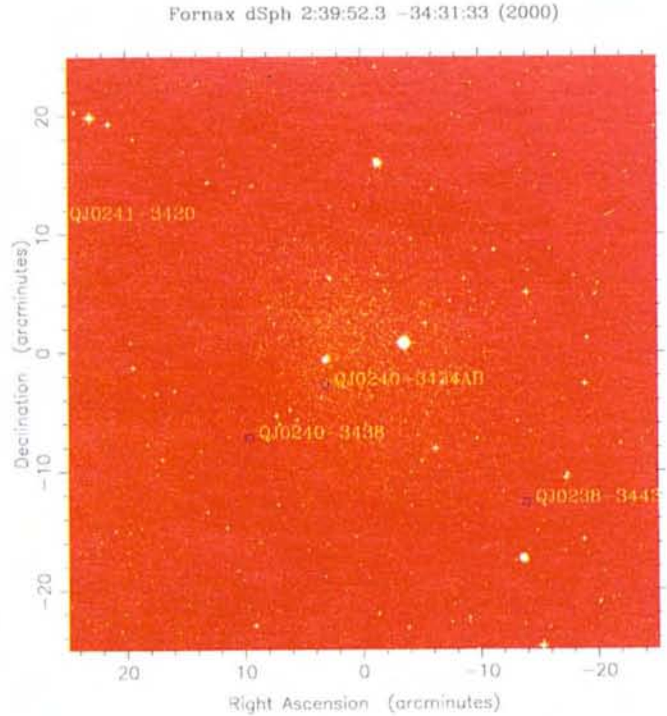
Since then, observations at two epochs (May and June 1994) of a field in the globular cluster NGC 6752 have been successfully carried out in excellent seeing (better than 0.5″) using SUSI on the NTT. These observations were centred on the known QSO Q1908-6002, and aimed to both test the astrometric limits to which SUSI could be pushed, and to measure the proper motion of NGC 6752 over a baseline of 18 months. Eighty-two reference stars were selected, based on their colour-magnitude diagram membership of the cluster, and used to define a linear transformation (with an allowed rotation) from a single frame in the first epoch to each of rest the frames. The typical one-sigma residuals in α and δ about these transformations were only 3.5 and 4.2 mas (respectively). This means that the position of a single object (i.e. the reference QSO) could be determined in α and δ at a single epoch to within 1.8–2.1 mas. This essentially confirms the expectation that the NTT/SUSI combination will be ideal for high-precision astrometry, and means that with observations carried out every other year over a six-year period, proper motions can be measured to ±0.2 mas/year*.

The Search for Reference Objects

It is therefore clear that, technically, there is no reason why proper motion programmes for the nearest satellite galaxies of the Milky Way (which are expected to have proper motions of 0.5–2 mas/year) can't be begun now. And scientifically, the rewards from such a programme would obviously be of incredible value to our understanding of the dynamics of the Local Group, the forma-

*Unfortunately, no subsequent observations of this field have yet been obtained in sufficiently good seeing to actually produce a proper-motion estimate for NGC 6752.





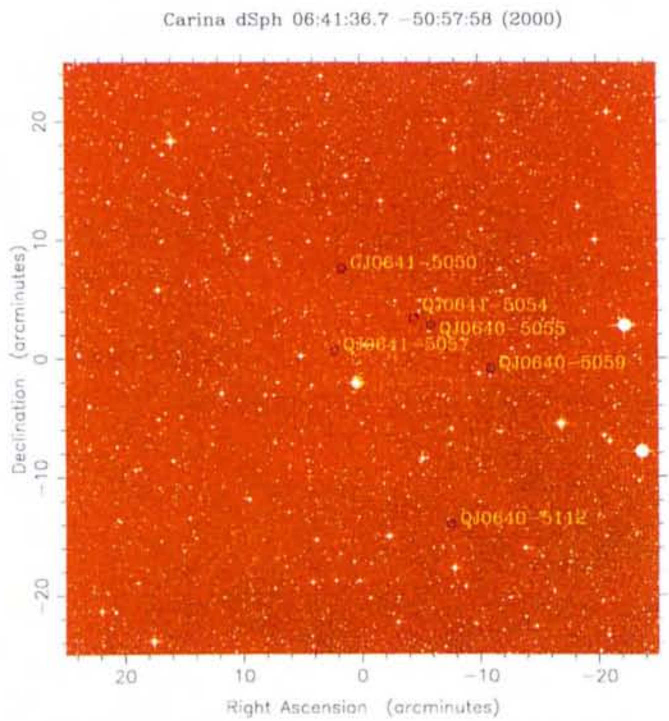


Figure 1.

tion of the Milky Way, and not least the total mass of the Milky Way (see, for example, Majewski (1994), Lynden-Bell & Lynden-Bell (1995) and reference therein).

The one thing stopping us, however, is that to measure such small proper motions, a distant and unresolved reference frame against which to measure motions is needed – i.e. reference QSOs. At the magnitudes at which this astrometry will be carried out (20–21.5 mag) the number density of QSOs is more than adequate to provide ≥ 5 QSOs behind the Dwarf Spheroidal (dSph) galaxies, and ≥ 20 – 100 behind the Magellanic Clouds. Unfortunately, QSO surveys tend (not unreasonably) to avoid such large sources of foreground contamination, meaning that almost no QSOs useful as astrometric references are already known. In 1994 we therefore began a programme of identifying QSOs useful as reference objects on the telescopes of La Silla.

Because our aim is to identify as many QSOs as possible, using as little telescope time as possible, we have used as many data as are available to us to construct lists of QSO candidates. This has included using UBVRI plate data from the 48″ UKST and CCD UBVRI data from the NTT, 3.6-m, MPIA 2.2-m and Danish 1.5-m to search for UV-excess candidates (the CCD data were required to calibrate the plate data, however, it was also searched for UV-excess candidates missed in the shallower plate data sets); using CCD UB data (from the same telescopes as above) to identify the optical counterparts to X-ray sources from ROSAT pointed observations; and, using CCD UB imaging to identify the optical counterparts to radio sources. QSO candidates identified using all these techniques were then spectroscopically observed using EFOSC1 (3.6-m), EFOSC2 (2.2-m), EMMI (NTT), and the RGO+FORS spectrographs on the Anglo-Australian Telescope (AAT). Our search strategy was made considerably more powerful by the flexibility of the EFOSC1/2 and EMMI instruments, which allowed a given night to be used for both imaging and spectroscopy, as dictated by changing weather conditions, and the available spectroscopic candidate lists.

The complete details of this programme will be published elsewhere (Tinney, Da Costa & Zinnecker, 1996), however, Figure 1 nicely summarises the main results to date, for the three primary targets of the Sculptor, Fornax and Carina dSph galaxies. In each case, 3–4 QSOs have been identified sufficiently close to the galaxy centre to have a network of reference stars suitable for astrometry.

Some Serendipitous Results

Figure 2 shows a sample of the spectra for the QSOs identified. Among the more interesting are QJ0240-3434AB and GJ0641-5059.

QJ0240-3434AB (The Fornax QSO Pair): Certainly the most dramatic result of the programme of spectroscopic follow-up was the discovery that the optical counterpart to one of the ROSAT sources behind the Fornax dSph is actually a pair of QSOs at $z = 1.4$ separated by 6.1″ (Tinney, 1995). The exact nature of this system is still unclear. With a separation of 6.1″, this system, if it is interpreted as a gravitational lens, has one of the largest separations known. Moreover, unlike the proto-typical lens 0957+561 (which has a similar separation), no lensing galaxy or cluster is obvious. Whether this system is a 'dark' lens, or a distinct QSO pair (possibly pointing to a high

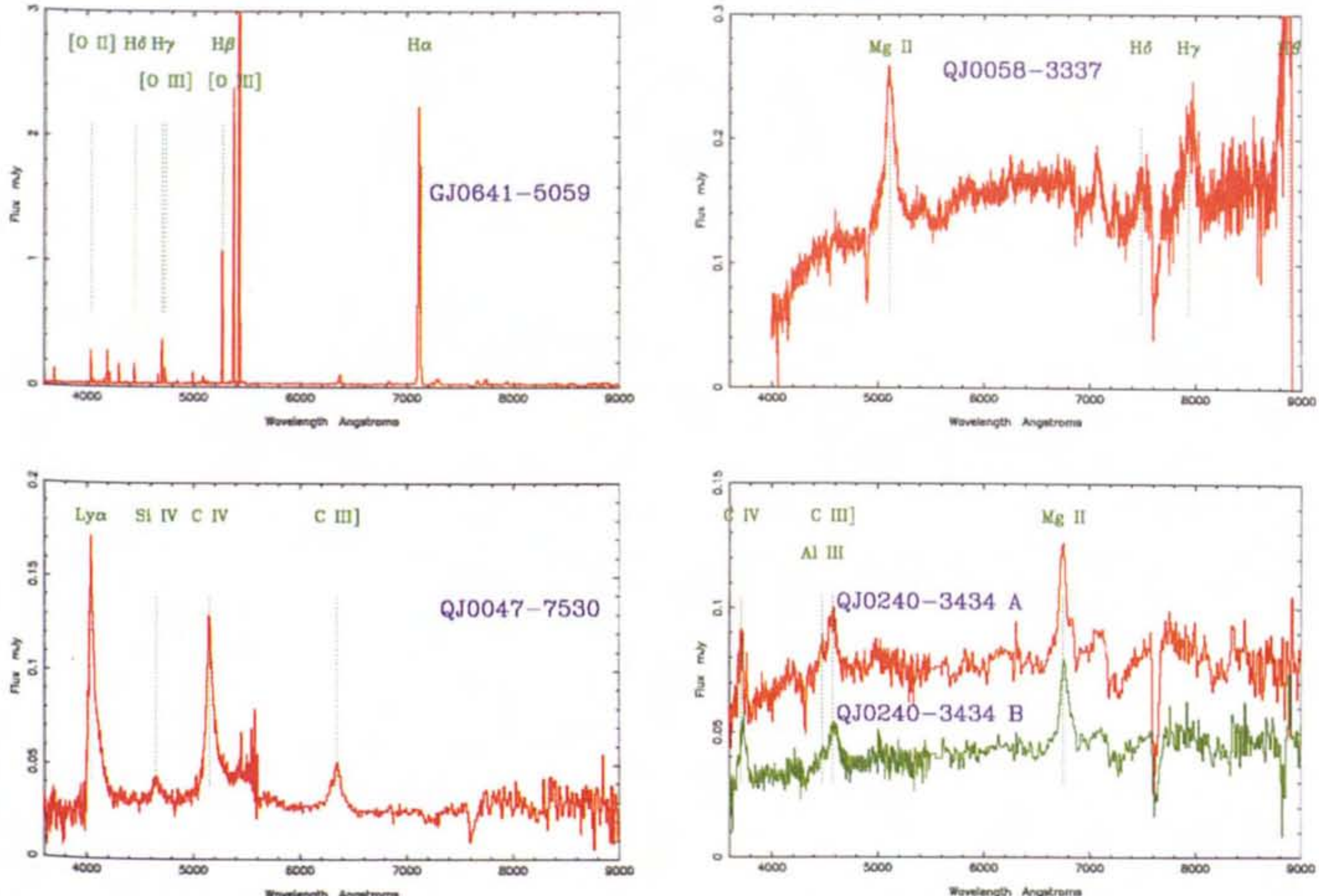


Figure 2.

redshift cluster), it clearly merits to be further studied, and monitoring is being attempted on the AAT.

GJ0641-5059: As its designation suggests, this emission-line galaxy was observed to be resolved and is not a QSO. However, it is still a remarkable object indeed. Its spectrum shows strong H Balmer lines, along with strong [O III], [Ne III], He I and [O II] – so much so that the continuum is almost invisible in the figure. All the lines are unresolved at 200 km/s. An examination of the line ratios shows the system to be a H II galaxy (rather than an AGN – Veilleux & Osterbrock, 1987). However, its extraordinarily high [O III]λ5007/Hβ ratio, places it among the most highly excited of such systems known.

Conclusion

We have found that standard QSO survey techniques can be efficiently applied to search for QSOs in arbitrary locations – i.e. behind nearby galaxies. Once such inertial reference objects have been identified, astrometric programmes targeted at these galaxies can be commenced with the NTT. In fact, the NTT will be extremely well placed to commence these programmes later this year, when service mode operations begin after its re-commissioning, since service mode observing offers the best chance of obtaining images in the excellent seeing conditions essential for these high-precision astrometric observations.

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A Multiline Molecular Study of the Highly Collimated Bipolar Outflow Sandqvist 136

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Introduction

Following the discovery of bipolar molecular outflows in the earliest 80's (Snell, Loren & Plambeck, 1980; Rodríguez, Ho & Moran, 1980), a wealth of observations have shown that this phenomenon is commonly detected in star-forming regions. During their earliest phase of evolution stellar objects are thought to generate a fast, well collimated bipolar wind that sweeps up the am-