1.4 Radio-Quiet Quasars

It was very quickly realized that the laborious task of examining the fields of radio sources was not the only way to find quasars. Any of the characteristics discussed above could be used to isolate quasar candidates. Ryle and Sandage (1964) noted that a search for *U*-excess objects would be particularly simple. The simplest approach is to take two photographs of a portion of the sky, one photograph with a *B* filter and one with a *U* filter. The relative exposure times are selected so that stars of spectral type A have equal intensities on the two photographs. Comparison of the photographs in a blink comparator leads to the immediate identification of all the *U*-excess objects, which form the minority of objects, as these have brighter *U* images than *B* images, unlike all of the cooler stars. At high Galactic latitude, contamination of the derived sample by O and B stars should be negligible.

This technique was employed very effectively by Sandage on the Mt. Wilson 100-inch telescope and by Lynds with the KPNO 84-inch telescope; in fact, the technique worked so well that many more UV-excess objects were found than suspected on the basis of the number of the surface density of known radio-selected quasars. Many of the first quasars selected by color were drawn from surveys for faint blue objects like

Source: Peterson, B.M. (1977) An Introduction to Active Galactiv Nuclei, Cambridge University Press.

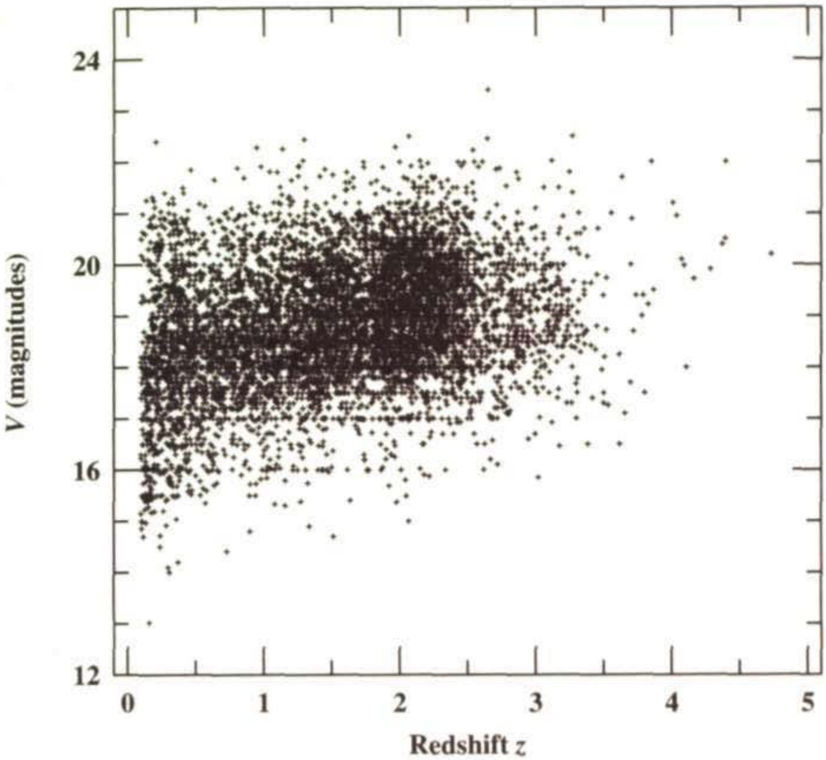

Fig. 1.9. The Hubble diagram (apparent magnitude vs. redshift) for 7031 quasars in the Hewitt and Burbidge (1993) catalog. The vertical width of the distribution is due to the broad quasar luminosity function, i.e., at any redshift, the wide range of apparent magnitudes is due primarily to the wide range of quasar absolute magnitudes.

white dwarfs and horizontal-branch stars such as the PHL ('Palomar–Haro–Luyten'; Haro and Luyten 1962) catalog. Sandage (1965), on the basis of further data obtained on the very wide-field ($6^{\circ} \times 6^{\circ}$) Palomar 48-inch Schmidt telescope, estimated that the total density of 'blue stellar objects' was as high as ~ 3 per square degree down to magnitude 18.5. After some initial confusion, it was realized that most of these high-latitude sources were in fact white dwarfs and RR Lyrae stars; nevertheless, there was a substantial population of quasar-like objects which could be optically selected. These were dubbed 'quasi-stellar objects', or QSOs. The terms 'quasar' and 'QSO' are, however, now used virtually interchangeably, except by purists, who still reserve the term 'quasar' for radio-loud quasi-stellar sources.

The long-wavelength SEDs of optically selected QSOs turn out to be markedly different from those of radio-selected quasars in that the radio emission (relative to the UV–optical–IR) is typically around 100 times lower in the radio. These so-called

Source: Peterson, B.M. (1977) An Introduction to Active Galactiv Nuclei, Cambridge University Press.

'radio-quiet' QSOs turn out to be 10–20 times more numerous than their radio-selected (or 'radio-loud') counterparts. The initial QSOs that were discovered, then, turn out to constitute a relatively small subset of the AGN population. As a result, attempts to construct 'unbiased' samples that are suitable for investigation of the QSO luminosity function (Chapter 11), for example, have concentrated on optical techniques. It is thus important to keep in mind that these optical surveys also detect the radio-loud objects. A simple illustration of this is that the radio-selected source 3C 273 is the brightest QSO in the sky in the optical and other wavebands as well – it will appear in virtually *any* QSO sample that covers the part of the sky where it is located. Therefore, care must be exercised in comparing the properties of 'radio-selected' and 'optically selected' quasar samples. The latter will be dominated by radio-quiet objects, but will not be free of radio-loud objects. Such samples sometimes may be used safely in statistical comparisons, but it is extremely dangerous to assume that individual objects in an optically selected sample are radio quiet, unless they are clearly below the detection limit of a radio survey and were not detected, but *should* have been detected if their spectral energy distribution is typical of radio-loud objects.

It is sometimes necessary to try to distinguish carefully between radio-loud and radio-quiet QSOs. A useful criterion (Kellermann *et al.* 1989) appears to be the radio–optical ratio R_{r-o} of specific fluxes (in, say, mJy) at 6 cm (5 GHz) and 4400 Å (680 THz); for radio-loud objects R_{r-o} is generally in the range 10–1000, and most radio-quiet objects fall in the range $0.1 < R_{r-o} < 1$. While this still leaves some ambiguous cases near the demarcation line, a criterion $R_{r-o} \geq 10$ for 'radio-loudness' appears to be appropriate.†

† This criterion means that on a log νF_ν diagram, the radio spectrum of a radio-loud object can fall as much as four decades below the optical spectrum (see Fig. 4.1).

Source: Peterson, B.M. (1977) An Introduction to Active Galactiv Nuclei, Cambridge University Press.