1.3.3 Ultraviolet Fluxes

Quasars are often found to have unusually blue broad-band optical colors. Johnson *UBV* photometry in particular shows that $U-B$ is remarkably small (i.e., large negative values), and this is often referred to as the 'ultraviolet (UV) excess' of quasars. Quasars occupy a region on the two-color diagram which is not heavily populated by stars, as shown in Fig. 1.6.

It must always be kept in mind that statements such as 'quasars are very blue objects' or 'quasars show an ultraviolet excess' are relative statements, which refer to their spectral energy distribution relative to stars. One must remember that in most stars there is relatively little flux in the U band; in cooler stars, the U band is in the Wien tail of the blackbody distribution, and in hotter stars, the Balmer continuum absorption edge occurs in the center of the band (i.e., at 3646 Å), so there is a real deficit in the number of photons in the shortward half of the band. Any AGN-type power-law spectrum shows a higher ratio of U flux to B flux than does an A star, even though there is really less energy per unit frequency at shorter wavelengths than at longer. Thus, the fundamental reason that quasars appear to have an ultraviolet excess is that quasar spectra are flatter than A-star spectra through the U and B bands.

1.3.4 Broad Emission Lines

The UV–optical spectra of quasars are distinguished by strong, broad emission lines. The strongest observed lines are the hydrogen Balmer-series lines (Hα λ6563, Hβ λ4861, and Hγ λ4340), hydrogen Lyα λ1216, and prominent lines of abundant ions (Mg II λ2798, C III] λ1909, and C IV λ1549); these lines appear in virtually all quasar spectra, but depending on the redshift of the quasar, some may not be observable if they fall outside the spectral window of a particular detector. Typical flux ratios are given in Table 1.1, along with typical equivalent widths, defined by

$$W_\lambda = \int \frac{F_l(\lambda) - F_c(\lambda)}{F_c(\lambda)} d\lambda, \tag{1.9}$$

where $F_l(\lambda)$ is the observed flux across the emission line at the wavelength λ, and $F_c(\lambda)$ is the continuum level underneath the emission line. Both of these quantities are specific fluxes that are conventionally measured in units of ergs s^{-1} cm^{-2} Å^{-1}, so the equivalent

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

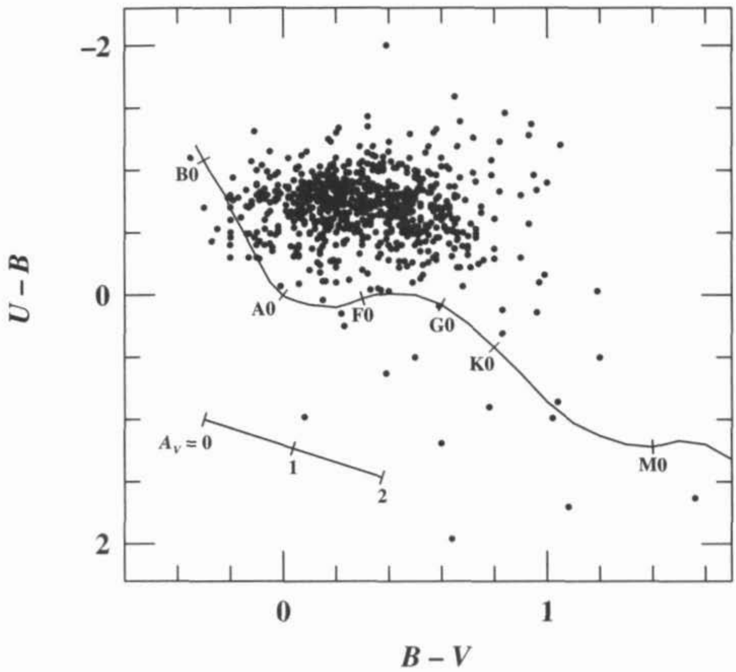

Fig. 1.6. The locations of 788 quasars from the Hewitt and Burbidge (1993) catalog on a two-color ($U - B$ vs. $B - V$) diagram. The locus of the zero-age main sequence, with spectral types indicated, is also shown. The line in the lower left shows how points will be translated due to amounts of reddening corresponding to visual extinction A_V (based on the extinction curve of Cardelli, Clayton, and Mathis (1989) with $R_V = A(V)/E(B - V) = 3.1$). Most quasars with measured UBV magnitudes are color-selected, i.e., identified as quasar candidates on the basis of their blue colors, especially $U - B < 0$.

width is measured in ångströms.† It is nearly always sufficient to approximate eq. (1.9) by

$$W_\lambda = \frac{F_{\rm line}}{F_{\rm c}(\lambda)}, \tag{1.10}$$

where $F_{\rm line}$ is the total line flux, usually in units of $\rm ergs\, s^{-1}\, cm^{-2}$.

† X-ray fluxes are sometimes given in units like photons $\rm s^{-1}\ cm^{-2}\ keV^{-1}$, so equivalent widths of X-ray lines are given in keV.

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

Table 1.1
Typical Emission-Line Strengths in AGNs

Line	Relative Flux (Lyα + N v = 100)	Equivalent Width (Å)
Lyα λ1216 + N v λ1240	100	75
C iv λ1549	40	35
C iii] λ1909	20	20
Mg ii λ2798	20	30
Hγ λ4340	4	30
Hβ λ4861	8	60

The correct interpretation of emission-line equivalent widths is that they provide an estimate of how large a continuum range one would need to integrate over to obtain the same energy flux as is in the emission line. This is especially relevant in the context of broad-band photometry of quasars; for example, if we compare the colors of high-redshift quasars, we find that the U band is greatly enhanced for quasars with $z \approx 2$, since the Lyα emission line then falls in the U band and alone attributes more than ~12% ($\approx W_\lambda(\mathrm{Ly}\alpha)/W(U)$, where $W(U) \approx 680$ Å, the width of the U bandpass) of the flux in the band. This means that in a flux-limited sample, quasars with strong emission lines in a given bandpass are more likely to be detected, which can thus lead to the erroneous conclusion that there are excess quasars at particular redshifts; we will return to this topic in Chapter 10.

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