# SPECTRAL INDEX VERSUS FREQUENCY AND MODELS FOR THE CONTINUA OF AGN AND QSOS

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ABSTRACT. The observed spectral index as a function of frequency of QSO continua must be explained in models. It is generally increasing ($F(\nu) \propto \nu^{-\alpha}$, $\alpha$ increasing) with higher frequency in the infrared (downward curvature). The visual to ultraviolet continuum has been shown to be a broken power law with $F(\nu) \propto \nu^{-0.5}$ at low frequency and a break to larger $\alpha$ at $\nu_o \sim 3\times10^{15}$ Hz. X-ray observations frequently exhibit a flat continuum with $\alpha < 1$. One prominent example is 3C273 for which $\alpha_{1-3\mu m} \rightarrow 2$, $\alpha_{vis} \sim 0.5$ and $\alpha_x \sim 0.5$. These spectral indices arise naturally in Secondary Electron Synchrotron Self-Compton (SESSC) models. Some accretion disk models approach these spectral indices for the visual-ultraviolet portion of the spectral distribution.

## 1. SUMMARY OF OBSERVATIONS

The observed spectral distributions of the continua of AGN and QSOs over the radio to $\gamma$-ray range of frequencies have been studied in many investigations. Space limitations in this format preclude an extensive review, therefore only some examples will be cited. The infrared spectral distributions are generally described approximately by power laws with spectral index $1 < \alpha < 2$ ($F(\nu) \propto \nu^{-\alpha}$) (Neugebauer et al. 1979). However, the spectral index generally increases with increasing frequency as seen in the case of 3C273 (Robson et al. 1983) for which $\alpha \approx 2$ at $\nu \sim 10^{14}$ Hz. Thus, there is downward curvature in these spectra at short infrared wavelengths.

Typically the visual to ultraviolet continuum is much flatter with spectral index $0 < \alpha < 1$ (Neugebauer et al. 1979, Richstone and Schmidt 1980). A peak in the spectral index distribution at these frequencies occurs at $\alpha \approx 0.5$. This flat power law continuum extends to the deep ultraviolet with a break to steeper index beyond $\nu \sim 3\times10^{15}$ Hz (Green et al. 1980, Bechtold et al. 1984).

The X-ray spectral distribution of these objects is described generally by a power law that is also rather flat with $0 < \alpha < 1$ (Zamorani et al. 1981, Mushotzky 1982, Worrall and Marshall 1984). The X-ray spectral index is much flatter than the visual to X-ray spectral index $\alpha_{ox}$. An example of the change in $\alpha$ as a function of frequency



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for the well studied object 3C273 has been discussed by Perry et al. (1987).

## 2. INTERPRETIVE MODELS

The multifrequency continua of many AGN and QSOs is generally represented by approximate equipartition of energy over all observed wavelengths. However, the spectra are not described by power law distributions over the many decades of electromagnetic frequency. The challenge for models is to explain the equipartition characteristic as well as the bumps and inflections.

One class of models to explain the large blue bump that serves as the photoionizing continuum is that of the thermal accretion disk (Shields 1978, Malkan and Sargent 1982). A difficulty with accretion disk models seems to be the frequently observed $F(\nu) \propto \nu^{-1/2}$ visual-ultraviolet continuum. Accretion disk spectral distributions generally tend to be excessively blue, that is $F(\nu) \propto \nu^{+1/3}$ (approximately) in the red (Madau 1987, Wandel and Petrosian 1988). A way of providing a better fit is to subtract an $F(\nu) \propto \nu^{-1}$ continuum from the visual spectrum as an extrapolation from the infrared. However, the infrared spectra at $\nu \sim 10^{14}$ Hz are frequently steeper than this (e.g., 3C273).

An alternative class of models are those of secondary electron synchrotron self-Compton (SESSC) emission (O'Dell, Scott and Stein 1987, Jones and Stein 1987, Stein 1987). Details are discussed in the references. In this class of models pp collisions inject electrons with $\gamma_e \approx 300$, typically, into the magnetic fields of the AGN. Synchrotron emission in high fields near a supermassive compact object naturally explains the $F(\nu) \propto \nu^{-0.5}$ visual-ultraviolet continuum. Synchrotron emission in the low fields associated with the emission line region explains the radio to infrared spectral distribution. Compton scattering from these sources results in an X-ray to $\gamma$-ray continuum. The spectral index $\alpha$ as a function of frequency is similar to that observed and equipartition of radiative luminosity is explained.

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