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An Empirical Ultraviolet Template for Iron Emission in Quasars as Derived from I Zw 1[1]

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ABSTRACT

We present an empirical template spectrum suitable for fitting and subtracting/studying the Fe II and Fe III emission lines in the restframe ultraviolet spectra of quasars and active galatic nuclei, the first empirical ultraviolet iron template to cover the full range of $\lambda1250-3090$Å. Iron emission is often a severe contaminant in optical–ultraviolet spectra of active galactic nuclei and quasars. Its presence complicates and limits the accuracy of measurements of both strong and weak emission lines and the continuum emission, affecting studies of line and continuum interrelations, the ionization structure, and elemental abundances in active galaxies and quasars. Despite the wealth of work on modeling the quasar Fe II emission and the need to account for this emission in observed quasar spectra, there is no ultraviolet template electronically available to aid this process. The iron template we present is based on *Hubble Space Telescope* spectra of the Narrow Line Seyfert 1 galaxy, I Zwicky 1 (I Zw 1, $z = 0.061$). The intrinsic narrow lines ($\gtrsim$ 900 km s^{-1}) of this source and its rich iron spectrum make the template particularly suitable for use with most active galactic nuclei and quasar spectra.

The iron emission spectrum, the line identifications, and the measurements of absorption and emission lines are presented and compared with the work of Laor et al. (1997b). Comments on each individual line feature and the line fitting are available in the Appendix. The methods used to develop and apply the template are also described. We illustrate the application of the derived Fe II and Fe III templates by fitting and subtracting iron emission from the spectra of four high redshift quasars and of the nearby quasar, 3C273, confirming their general applicability to active galaxies despite the somewhat unusual properties of I Zw 1. We briefly discuss the small discrepancies between the observed iron emission of these quasars and the ultraviolet template, and compare the template with previously published ones (Wills, Netzer & Wills 1985; Corbin & Boroson 1996; Verner et al. 1999). We discuss the advantages and limitations of the

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UV Fe II and Fe III templates and of the template fitting method. We conclude that the templates work sufficiently well to be a valuable and important tool for eliminating and studying the iron emission in active galaxies, at least until accurate theoretical iron emission models are developed.

The Si IV+O IV] λ 1400 feature in I Zw 1 is clearly strong relative to C IV λ 1549, and C IV and C III] λ 1909 are both relatively weak. This may partially be due to the higher densities and lower ionization parameter prevailing in Narrow Line Seyfert 1 galaxies (Kuraszkiewicz et al. 2000), and to the big blue bump shifting towards lower energies in more luminous Seyferts, such as I Zw 1. In I Zw 1 the narrow line width reveals that C III] is heavily blended with Si III] λ 1892, Al III $\lambda\lambda$ 1854,1863, and Fe III transitions. This suggests that the C III] line strength and width may be overestimated in many quasar line studies where the lines are broader and deblending is not possible. This affects density estimates of the broad line region. Photoionization modeling, including all these line features, and subsequent fitting to the spectra are required to estimate the true C III] strength. We also argue, based on earlier work, that (strong) iron emission may be connected with high densities and associated with outflows.

Subject headings: galaxies: active — galaxies: Seyferts: individual(I Zw 1) — methods: data analysis — quasars: emission lines — quasars: individual (3C273, Q0020+022, Q0252+016, Q1629+680, Q2345+061)

1. Figure 4

Fig. 4.— Suggested identifications of individual, mostly unblended UV Fe II and Fe III emission multiplets based on the positions and (rough) strengths listed by Moore (1950). Each label consists of the ionizatation level and the multiplet number separated by a hyphen. Multiplets with labels in parentheses are slightly blended. Square brackets denote multiplets which are suggested present by the fitting process (see Appendix A; '2-10' is expected only). Heavily blended multiplets are not marked. Multiplets with labels ending with an 'm' have relative transition strengths inconsistent with the optically thin laboratory strengths. Note that the positions in the spectrum of the multiplet transitions are sometimes blueshifted by 1-2 Å relative to the laboratory wavelengths marked. This is particularily evident for Fe III UV34 at ∼1912 Å (labeled '3-34m'). See § 5.2 and Appendix A regarding the relative strengths in this multiplet.

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