A study of FeII/MgII flux ratio in quasars.

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Introduction

According to current chemical enrichment scenarios, alpha-elements such as magnesium are produced predominantly in Type II Supernovae (SNe II), while iron is produced predominantly in SNe Ia. Because of the difference in lifetime of their progenitors, iron enrichment delays relative to alpha-elements by about 1 Gyr. If FeII/MgII, the relative strength of Fe II emission lines and the Mg II 2798 doublet, reflects the Fe/Mg abundance ratio, there will be a break in FeII/MgII at high redshift. Despite of much efforts made by many observational groups, there have been found no signs of such a break. FeII/MgII looks constant from low-redshift up to z=6.4 with large scatter (see Fig.1).

Tsuzuki et al. (2006) observed 14 low-redshift ($z < 0.56$) quasars and found that there is a correlation between FeII/MgII and black hole mass M_{BH}. This indicates that FeII/MgII varies with non-abundance factor such as M_{BH}. If that correlation can also be applied to high-redshift quasars, we have to correct this effect in order to estimate accurate Fe/Mg abundance ratio.

To check the corrlaion in higher redshift quasars, we observed six quasars at z~2 with GMOS on Gemini South Telescope.

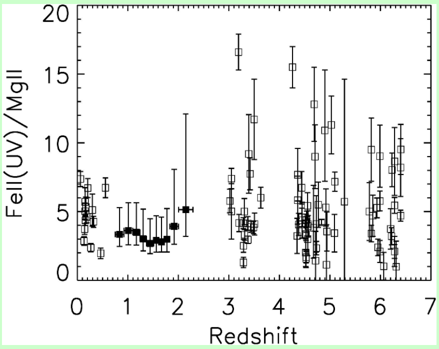

Fig. 1. FeII/MgII vs. redshift

Observation

We observed six quasars at z~2 with GMOS in the long-slit mode on Gemini South Telescope. Table 1. shows the observing log. Individual spectral frames were processed using the Gemini IRAF package version 1.9.1. Reduced spectra are shown in Fig. 2. The shaded area indicates the region where the spectra are affected by telluric absorption, and corrections for these features are not applied. Since B0226-104 is terribly affected by telluric absorption, we can not measure its MgII flux.

Table 1. Observation Log

Object	Redshift	M_B	Exp Time	Date
B0226-104	2.276	-29.7	120sec	2004 Sep 18
B0421+019	2.059	-27.8	600sec	2004 Sep 18
CTQ254	2.118	-27.7	1500sec	2004 Sep 18
FIRSTJ2149-0811	2.128	-28.9	150sec	2004 Sep 20
LBQS2209-1842	2.093	-27.4	960sec	2004 Sep 20
PHL424	2.087	-28.5	300sec	2004 Sep 21

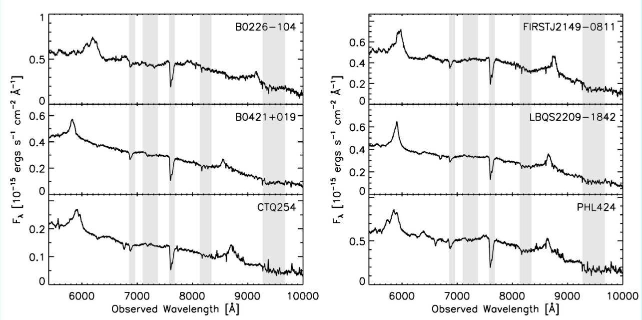

Fig. 2. Reduced Quasar Spectra

Results and Discussion

We measured FeII/MgII for 5 quasars (except for B0226-1049), and Fig.3 plot the results (*red circles* are our results). In order to check the FeII/MgII-M_{BH} correlation in these quasars, Fig.4 compares our results with low-redshift data in Tsuzuki et al. (2006) (*filled circles* are our results; *open circles* are the results in Tsuzuki et al.). As can be seen in Fig.4, our quasars do not follow the correlation. All of our quasars have FeII/MgII greater than expected from the correlation.

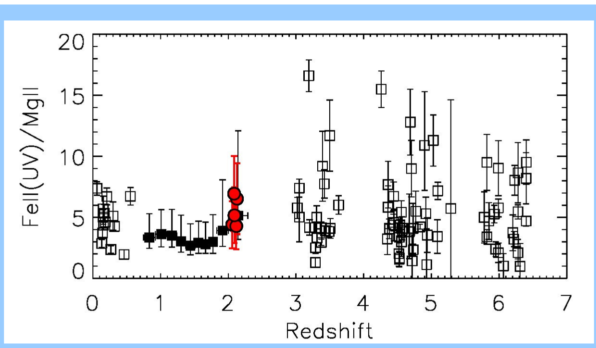

Fig. 3. Results

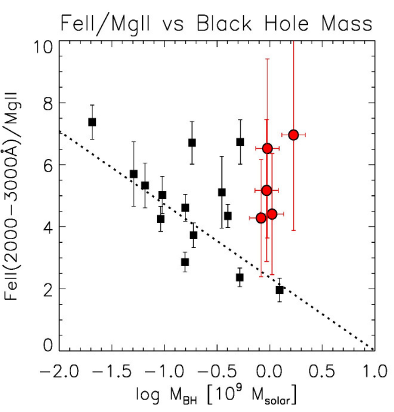

Fig. 4. FeII/MgII vs. M_{BH}

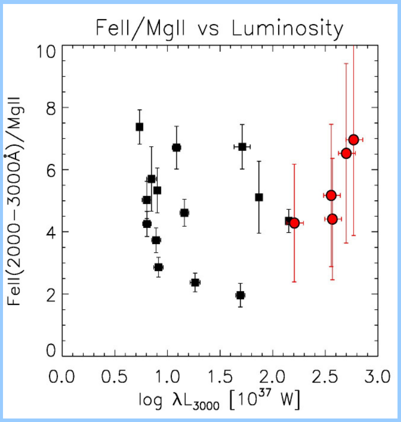

Fig. 5. FeII/MgII vs. Luminosity

Since our quasars are much luminous than low-redshift quasars, we checked luminosity effect. Fig.5 compares FeII/MgII with luminosity. As shown in Fig.5, luminosity is not responsible for the large FeII/MgII value in our quasars. The *real* cause would be evolution in Fe/Mg abundance ratio *or* non-abundance effects such as the spectral energy distribution of the continuum from the central source, the strength of the radiation field and the gas density of Broad Line Region (BLR) clouds as well as the microturbulence of BLR gas.

It is interesting to note that Yoshii et al. (1998) calculates chemical evolution model and predicts that FeII/MgII flux ratio will decline 3 Gyr after the initial burst of star formation, because the metal-deficient gas having the low Fe/Mg abundance ratio of genuine SNe II origin is released in the interstellar matter from the surface of low-mass starts with lifetimes greater than 3 Gyr. Fig.6 shows the predicted FeII/MgII evolution. If a cosmology with Ω_m=0.3, Ω_Λ=0.7, H_0=70km/s/Mpc is assumed, the age of the universe becomes 3 Gyr at z~2.15. In order to check whether this is true or not, measurements of FeII/MgII in quasars at around z~2.15 are cruicially necessary.

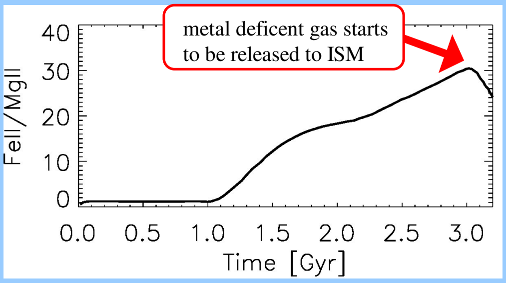
metal deficent gas starts to be released to ISM

Fig. 6. Predicted FeII/MgII evolution

Future Work

To check the effects of non-abundance factors to the FeII/MgII, further investigaions are required using large samples of quasars. Therefore we have started to analyze the SDSS quasar data. We confirmed that there is a correlation between the FeII(UV)/MgII and the FWHM of MgII. Fig. 7 shows this correlation (*Dot* denotes SDSS quasar with $z < 2$, *red circle* denotes our quasar). This is quite similar to the correlation found in so-called ‘Eigenvector 1’ space (cf. Sulentic et al. (2002), etc), so it may well be that the same physics works also on FeII(UV)/MgII. As can be seen in Fig. 6, FeII(UV)/MgII varies largely with FWHM(MgII), so that this effect may make the scatter seen in high-redshift quasars in Fig. 1 or Fig. 3. We suggest that application of correction for this effect to high-redshift quasars may make it clear where the break is.

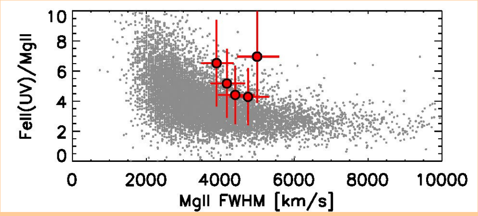

Fig. 7. FeII(UV)/MgII vs. FWHM(MgII)