NEAR-INFRARED SPECTROSCOPY OF SEYFERT AND STARBURST GALAXIES

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The Brackett α and γ lines of atomic hydrogen, molecular hydrogen H_2 v=1-0 S(1) line and [FeII] 1.644 μm line were observed in type 1 and type 2 Seyferts, LINERS, starburst galaxies, and interacting galaxies. For the observations, the Infrared Spectrometer (IRS) with an array of eight InSb detectors was used on the CTIO 4 m and 1.5 m telescopes. The effective size of the slit is 6.8"x4.3" on the 4 m and 10.3"x20.7" on the 1.5 m. The resolution of the IRS was 290 km s^{-1} at 2 μm.

In the Brackett α and γ observations of starburst and Seyfert galaxies, the Brackett α line has been detected in seven of twelve galaxies as well as Brγ. The extinction can be estimated the ratio of Brα to Brγ. Assuming Case B recombination at 10^4 K and an electron density of 10^4 cm^{-3} and using the van de Hulst No.15 reddening curve, we predict Av = 50 log (Brα/Brγ/2.8) we find a good correlation between the extinction Av and the optical depth of the silicate absorption τ(10) at 10 μm. Figure 1 shows a plot of log(Brα/Brγ) versus τ(10). If the data points (2 and 9) for the type 2 Seyfert galaxies NGC 1068 and NGC 5506 are excluded, a line with slope Av/τ(10) = 14 is obtained as a best fit to the data points. This value of Av/τ(10) is in excellent agreement with the range (8.5-17.5) obtained from measurements of galactic objects. The points for NGC 1068 and NGC 5506 would appear to lie significantly above the line for Brα/Brγ = 2.8 and Av/τ(10) = 14. An intrinsic value Brα/Brγ = 9(+3/-3.5) is suggested for both galaxies. Alternatively if their nuclei contain highly obscured Seyfert 1 sources, τ(10) measurement may be significantly underestimaterd due to scattered light filling the observed silicate absorption profile. For comparison of the extinction values derived from Brα/Brγ with those determined from optical and X-ray observations and the implications, see Kawara, Nishida, and Phillips (1989).

In the [FeII]1.644 μm observations (Kawara, Nishida, and Taniguchi 1988), we find that (1) the [FeII] line widths of Seyfert are considerably broader than those of starburst galaxies; (2) the [FeII] intensity relative to the Brγ line intensity is stronger in

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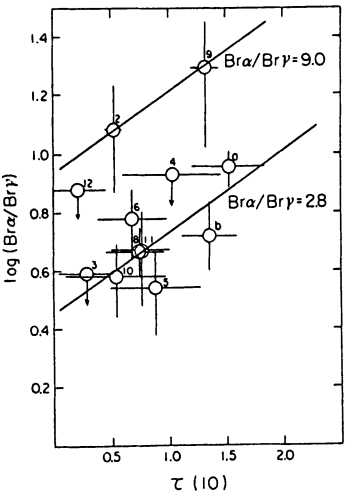

Fig. 1. A plot of log (Br α / Br γ) against τ(10), the depth of silicate absorption. Two reddening lines of slope, Av/ τ(10) = 14 are shown.

Seyferts than in Starburst galaxies; (3) seyferts and starburst galaxies has almost same intensity ratio of FeII to H_2 v = 1-0 S(1) in our limited sample, suggesting that both [FeII] and H_2 emission are closely related and thus due to shock excitation. The origin of [FeII] emission may be due to a starburst wind for starburst galaxies and due to a wind and/or X-ray from the AGN for Seyferts which generates enhanced FeII emission; and (4) [FeII] profile of NGC 1068 is strongly asymmetric with no or very faint blue component. Taking into account this fact, the same asymmetry found in Br γ , and the symmetric Br α profile, we hypothesize an optical thick cloud or disk material (Av > 23) along the line of sight to the nucleus.

In the molecular hydrogen emission survey, we detected the H_2 v = 1-0 S(1) (or S(3)) in about 40 out of a sample of 52 galaxies of various types, including type 1 Seyferts/QSO (Kawara, Nishida, and Gregory 1987, 1988). In five out of 13 Seyfert 1s/QSOs, H_2 emission have been detected. The positive detection includes NGC 3783 with a "bare" Seyfert 1 nucleus and an IR QSO IRAS 1334+246. The luminosity of H_2 S(1) (or S(3)) emission of normal Seyfert 1s ranges 10^5 to 5×10^7 $L_\odot$, comparable to those of unusually dusty Seyferts or larger. The H_2 emission is much stronger in unusually dusty AGN than in starburst galaxies. The H_2 luminosity in both AGN and starburst galaxies is 100 times higher than that predicted from the models of population of OB stars and proto-stellar objects. This supports the hypothesis that X-ray photons or a wind from the AGN is responsible for H_2 emission in AGN galaxies. We note that the previously reported strong line H_2 v = 2-1 S(1) in NGC 3227 was not confirmed in our observation, suggesting that UV fluorescence is probably excluded for extragalactic H_2 emission.

Comparing [FeII] and H_2 v = 1-0 S(1) line intensity with optical emission line intensity, we find good correlations between [FeII] 1.644 μm/Br γ and [OI] λ6300 / H α and between H_2 S(1)/Br γ and [OI] 6300/H α (Mouri et al. 1988).

References

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