The Possible Relation between Star Formation Rate and Accretion Rate in Different Type of AGNs

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Abstract: **It is argued that there is a linear correlation between star formation rate (SFR) and accretion rate for normal bright AGNs. However, it is still unclear whether this correlation holds for LINERS, the accretion rates of which are relatively low and radiatively inefficient accretion flows (RIAFs) are believed to present in them. In this work, we derived the accretion rate of LINERs from the hard X-ray luminosities, based on spectral calculations for RIAFs. We find that LINERs follow the same correlation between SFR and accretion rate defined by normal bright AGNs. This means that the gases feeding black hole and star formation in low-luminosity LINERs may follow the same pattern as those in normal bright AGNs, which is roughly consistent with recent numerical simulations on quasar evolution.**

1. Aim

To explore whether the low luminosity AGNs (use LINERs as an example) follow the same correlation between accretion rate and SFR defined by normal bright AGNs or not.

2. The sample

We adopt the sample given by Satyalpal et al. (2005) for our present investigation, which include 33 LINERs (having compact X-ray core), 54 Seyferts, 15 quasars, 14 radio galaxies, and 14 NLS1's. All of which have estimated BH mass, FIR and bolometric luminosities.

3. Relation between LX,2-10keV and $\dot{m}$ for RIAFs

Standard thin disk is believed to be present in bright AGNs (e.g., QSO, Seyfert, etc.), which is optical thick, geometrically thin and radiatively efficient ($\eta = 0.1$).

RIAFs is optical thin, geometrically thick, two-temperature hot accretion flows, which is assumed to be present in LLAGNs (e.g., Narayan et al. 1998). The parameters and their typical values in spectral calculations are viscosity, $\alpha = 0.1$, ratio of gas to total pressure, $\beta = 0.8$, outer radius, Rout=200RSchw, and fraction of dissipated energy directly heating the electrons, $\delta = 0.1$.

For a fixed BH mass, MBH=10^8Msun, the dependence of the 2-10 keV X-ray luminosity on accretion rate of RIAFs can be roughly fitted by a single power law:

$$\log L_{X,2\text{-}10\,\mathrm{keV}} = (2.37 \pm 0.06) \log \dot{m} + (46.33 \pm 0.22) \quad \text{(Eq. 1)}$$

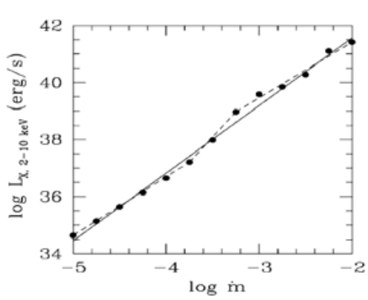

FIG. 1.—Integrated 2–10 keV X-ray luminosity vs. the dimensionless accretion rate $\dot{m}$ predicted by the RIAF model (*filled circles with dashed line*). The solid line is a linear fit of $L_{X,\,2-10\,\mathrm{keV}}$ to the model-calculated points (*filled circles*). Model calculations are carried out for a $10^8\ M_\odot$ black hole, with $\alpha = 0.2$, $\beta = 0.8$, and $\delta = 0.1$.

The X-ray luminosity is roughly proportional to the BH mass, so we calculate the accretion rate through Eq. 1 if X-ray luminosity and BH mass is given.

4. Result

4.1 Mass accretion rate and SFR of different type of AGNs

We calculate the mass accretion rate of the normal bright AGNs (e.g. quasar, Seyfert, and NLS1s) with $\dot{M} = L_{Bol}/\eta c^2$, where $\eta = 0.1$ is assumed. The low luminosity LINERs is calculated with Eq. 1.

SFR of all sample is calculated from L_{FIR} by using a calibrated formula in which the old stars contribution have been properly subtracted (see satyapal et al. 2005 for more details).

$$\mathrm{SFR_{FIR}}\,(M_\odot\ \mathrm{yr^{-1}})\,\frac{1.75 f L_{\mathrm{FIR}}}{6.38\times10^9\ L_\odot} = \frac{f L_{\mathrm{FIR}}}{3.63\times10^9\ L_\odot}, \quad f = \begin{cases} 1+\sqrt{5.71\times10^8\ L_\odot/L_{\mathrm{FIR}}} & L_{\mathrm{FIR}} > L_c, \\ 0.75\left(1+\sqrt{5.71\times10^8\ L_\odot/L_{\mathrm{FIR}}}\right) & L_{\mathrm{FIR}} \le L_c \end{cases}$$

4.2 Relation of the mass accretion rate and SFR

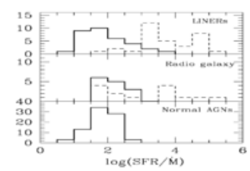

FIG. 2.—Histogram of SFR/$\dot{M}$ for the sources in the sample: 33 LINERs (*top*), 14 radio galaxies (*middle*), and 81 normal bright AGNs (52 Seyferts, 15 quasars, and 14 NLS1's; *bottom*). The dashed lines in the top and middle panels show results of Satyapal et al. (2005), while solid lines are ours.

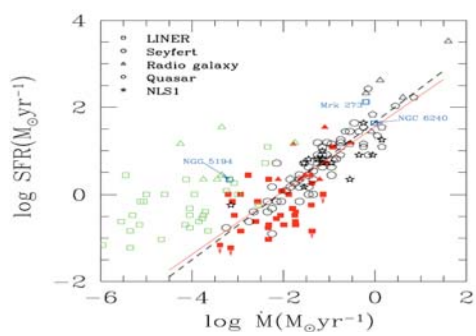

Fig.3 Relation of Mdot and SFR. Green open squares show results of Satyapal et al. 2005, where $\eta = 0.1$ is assumed in calculating the Mdot, which may be incorrect for the low luminosity LINERs and radio galaxies. The red solid squares are our re-estimated accretion rates. Red line is linear fit to the whole 128 sample, while dashed line is for normal bright AGNs.

5. Conclusion

(1) We re-estimated the mass accretion rate of the low-luminosity LINERs with RIAF spectra calculations.

(2) We find that the SFR/Mdot of the LINERs and radio galaxies is similar to that of bright normal AGNs (Fig. 2) .

(3) The low luminosity LINERs follow the same correlation defined by the normal bright AGNs when typical parameters of RIAF is adopted. It indicates that BH accretion evolve in the same way as star formation: both are regulated by the interstellar gas in the host galaxies. This conclusion is consistent with the simulation of the quasar activity triggered by galaxies merger (e.g., Springel et al. 2005).

REFERENCE:

(1) Wu. Q. W. & Cao X. W. 2006, PASP, 118, 1098 (See more details)

(2) Satyapal et al. 2005, ApJ, 633, 86;

(3) Springel et al. 2005, MNRAS, 361, 766

(4) Narayan, et al. 1998 in Theory of BH accretion disks, 148