Feeding Compact Objects: Accretion on All Scales
Proceedings IAU Symposium No. 290, 2012
C. M. Zhang, T. Belloni, M. Méndez & S. N. Zhang, eds.

doi:10.1017/S1743921312019941

The Origin of Weak Emission-Line AGNs

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Abstract. Some abnormal AGNs are discovered in the SDSS data recently. The usual UV/optical emission lines are exceptionally weak in their UV/optical spectroscopy, though the shapes and luminosities of their continua are comparable with that of the normal AGNs. We investigated the optical variations and the near-infrared spectra of these weak emission-line AGNs. We propose that these AGNs can be interpreted as the early stage of an active cycle of AGNs.

Keywords. Quasars: emission lines, line: formation, infrared: galaxies

The presence of strong emission lines is one of the most important features used to distinguish AGNs from normal galaxies. However, a handful of puzzling AGNs with extremely weak emission lines are recently found in SDSS data (Diamond-Stanic *et al.* 2009; Plotkin *et al.* 2010). Due to their weak radio emissions and low polarizations in optical continua, the boosted synchrotron emission from relativistic jets in AGNs is unlikely to be the origin of weak emission lines (Heidt & Nilsson 2011). In addition, we have conducted photometric monitoring on seven weak emission-line AGNs and not found any significant micro-variation (see Figure 1 for two examples). Up to now, the origin of this rare kind of AGNs is still unclear, though several scenarios are proposed to explain the weakness of the emission lines, e.g., the early stage of an active cycle of AGNs, cold accretion disk, super-Eddington accretion, and shielding gas (Baskin & Laor 2004; Hryniewicz *et al.* 2010; Laor & Davis 2001; Liu & Zhang 2011; Wu *et al.* 2011).

To distinguish the above models, one of the key factors is the accretion rate or Eddington ratio. Due to the relatively high redshift of the weak line AGNs ($z = 0.4$–2.5), some of the optical emission lines are expected to present in the near-infrared band. We observed three sources by TripleSpec on Hale 5m telescope. In the following, we will show the hint and puzzle brought by the near-infrared spectra.

(1) Prominent broad Hα lines are found in the near-infrared spectra (the equivalent width is about 130 Å, see Figure 2). This means there are efficient ionization photons. Therefore, we think the "cold disk" model is unlikely.

(2) We plot the three sources in mass-luminosity plane using the inferred black hole mass from Hα lines. The results clearly rule out the super-Eddington scenario. One source marginally crosses the critical line of the cold disk if $a_* = 0$. However, it seems that the high spin of the black hole in this source avoids the cold accretion disk.

(3) The narrow lines, e.g. [OIII] λ5007, are also weak in the near-infrared spectra, which is hard to explain under the scenario of "shielding gas".

(4) The evolving scenario can explain the properties found in the near-infrared spectra. More specifically, the broad line region forms before the narrow line region, and low-ionization lines (Hα and Hβ) form before high-ionization lines (Mg II and C IV). The Balmer decrement of SDSS J1252+2640 is quite large (>7), which may indicate the dusty environment of the BLR in the early stage of an AGN. Actually, the overall

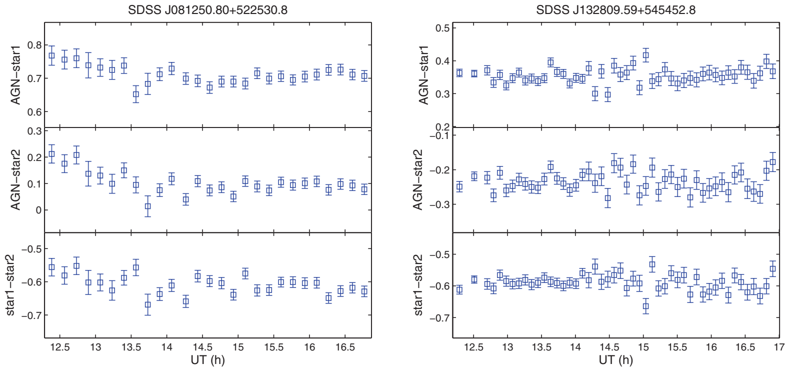

Figure 1. Two examples of the differential light curves (R band) of weak emission-line AGNs.

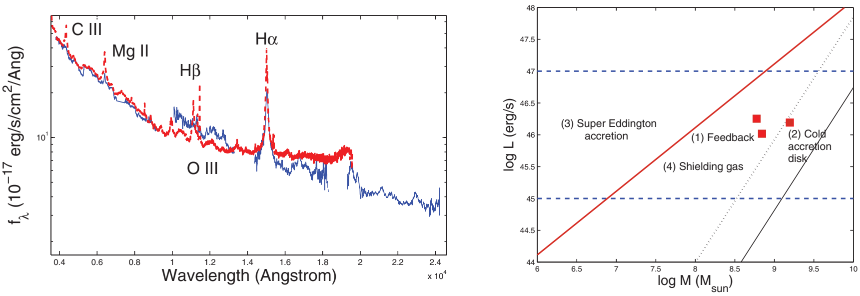

Figure 2. The example (SDSS J125219.47+264053.9) of the optical and near-infrared spectra of weak line AGNs (left). Solid lines are the spectra of SDSS and TripleSpec. Dashed line is the composite spectrum of QSOs in SDSS. The models proposed to explain weak line AGNs occupy different regions in the mass-luminosity plane (right). The rough interval of the bolometric luminosity of weak line AGNs is indicated by the dashed lines, i.e. $10^{45} - 10^{47}$ erg/s. The thick solid line is the Eddington limit. The dotted line ($a_* = 0$) and thin solid line ($a_* = 0.998$) are the criteria of the cold accretion disk. The squares are the three sources observed.

property of the three source is quite similar to PG 1407+265 (McDowell *et al.* 1995). Although the current result is quite instructive, we still need a larger sample to strengthen the above conclusions.

This work is supported by the National Basic Research Program of China (grant 2009CB824800) and the NSFC (grants 11103019, 11133002, 10821061, and 10725313).

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https://doi.org/10.1017/S1743921312019941 Published online by Cambridge University Press