MATTER OUTFLOW FROM ACTIVE GALACTIC NUCLEI

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Some problems of the theory of matter outflow from AGN in connection with the unification model of AGN are brifly discussed.

1. Introduction

There are two apparent manifestations of matter outflow from active galactic nuclei (AGN): first – relativistic jets, and second – the gas outflows, visible in absorption in the ultaviolet (UV) and the X-ray bands. Now some definite consensus exists about the electromagnetic nature of the accelerating and collimating forces acting to the jets, but still there is no common approach to the "absorbing outflow" theory. Here we brifly discuss some approach to the last problem.

New generation of cosmic telescopes brought many new results, including precise spectral observations of absorption in UV and X-ray bands of the AGN spectra. Some specific difficulties of the interpretation of the new data were noted by Ray Weymann in his review of the conference, devoted to the mass-outflow problem [1]:

- the "local covering factor", that is the part of the continuum radiation source shadowed by the absorbing gas at a defined velocity, which has no commonly accepted interpretation;
- differences of the column densities derived from X-ray and UV absorptions (usually the last seems to be much less);
- stability of the narrow details in the structured absorption profiles of some objects, both in luminous broad absorption line quasars (BALQSO) and in low luminosity AGNs (the Seyfert galaxies), the brightest instances of those are Q1303+308 and in NGC 4151 objects.

Below we will brifly discuss the main points of our theory of the matter outflows, which can explain the observational data.

2. The interacting subsystems of AGN, evolution and unification scheme

Our theoretical approach to the problem of matter outflow from AGN was presented in the paper [2], where we have suggested the theory and model of the BALQSO outflow, based on the concept of the "interacting subsystems approach". This approach supposes that AGN consists of three main physically distinct, but strongly interacting subsystems: the central super-massive black hole (SMBH), compact stellar cluster (CSC), and gas subsystem (GS). The last one usually includes the accretion disk (AD), the obscuring torus (OT) and the hot gas (HG) outflowing through the hole of the torus. The observational signs of the hot gas were provided by the present generation X-ray missions XMM-Newton and Chandra. The interpretation of the data shows the signs of presence of a hot gas with temperature $T\sim10^7$K, which can provide the confinement of "cold" clouds with temperature $T\sim10^4$K. The second subsystem postulated in [2] was the compact and heavy stellar cluster (CSC) with the mass close to the MBH mass. As it was shown in [2], the role of the CSC is essential for the dynamics of the hot gas, which is stromgly influences the absprbing (cjld clouds) matter dynamics. Now the first observational evidences of presence of the CSC in AGN was provided by recent observations of AGN structure in the 0.1' resolution scales [3].

Considering the AGN evolution, we first of all stress that it is driven mainly by intergalactic interactions and merging processes. Every merging events lead to a new "duty cycle" of the AGN activity, accompanied by the starburst event in the earlier stage [3] .

The corresponded evolution sequence of AGN during a duty cycle is schematically shown in Fig.1; note that the picture is remarkably similar to the evolution scheme derived from IR observations. It is worth noting that this picture of evolution is very well compatible with the standard geometrical unification model [4]. The physics of obscuring torus (OT) is inevitably connected with the existence of the compact stellar cluster produced by a starburst in the center of AGN.

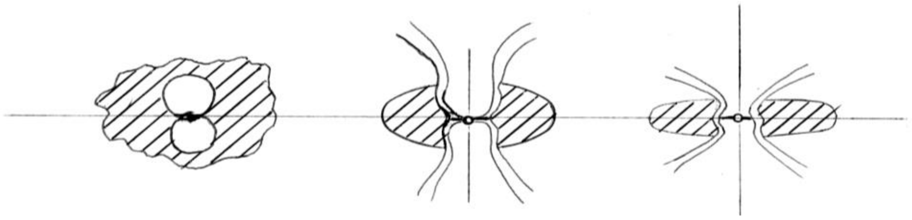

Fig 1

So, from the evolution scheme presented above, the unifying model follows, which includes both the "classical" AGN1-AGN2 unification and the absorbing outflow models, which predicts the appearance of the spectral absorption features as the broad absorption lines in UV and absorptions in the X-ray band.

Some specific properties of the spectral lines radiation absorption along the absorbing layer of the clouds in the cloudy media in the broad absorption line QSOs (BALQSOs) was first considered in our paper [2]. We used the equation for the change of the radiation flow $\Phi(\nu)$ due to absorption radiation in spectral lines in the form

$$d\Phi(\nu)/dr=-\Phi(\nu)N_{cl}S_{cl}\{1-\exp[-\Sigma_j\varphi(\nu-\nu_j)\tau_j]\}, \quad (1)$$

where N_{cl} is space density and S_{cl} the cross-section of clouds at the r distance, τ_j is the optical depth of a cloud in the line center, $\varphi(\nu-\nu_j)$ – the normalized Doppler (Gaussian) profile of the j-th line, and $\nu_j=\nu_{j0}*(1+V_{cl}/c)$. The similar equation for the continua photoelectric absorption is:

$$d\Phi(\nu)/dr=-\Phi(\nu)N_{cl}S_{cl}\{1-\exp[-\tau(\nu_D)]\}, \quad (2)$$

where $\nu_D = \nu(1+V_{cl}/c)$.

The “local covering factor” provided by clouds with cross-section S_{cl} in the $\Delta r= V_T/(dV/dr)$ cloudy slab (which serves as a “Sobolev length”) at velocity V(r) is $F(V)\sim n_{cl}S_d\ \Delta r\ (S_{cl}/S_d)\sim n_{cl}\ S_{cl}\ V_T/(dV/dr)$. Obviously, the covering factor at that velocity can be small enough when the velocity gradient is large. Accordingly, the apparent absorption in a line will be small in this case even if the line opacity in the individual cloud is large. The situation is quite different in the case of continuum absorption, because the widths of the absorption strips (in the case of photoelectric absorption) are much wider then the turbulent widths of the absorption lines. This could explain the different estimations of the empirical column densities from UV line absorptions and the X-ray continuum absorption.

The considered dependence of the covering factor on the cloud acceleration is also related to the so-called “line-locking effect”, due to appearance of the non-linear connection of the radiation pressure force to the acceleration of the clouds and the velocity gradient. We used our dynamical model to calculate the gas dynamics in the two-phase medium and the resulting spectrum of the well-known object, showing the line-locking effect, the BAL quasar Q1303+308.

The calculated spectrum (gray line) in comparison to the observed one (black) is shown in Fig.2. One can see that it is rather good similarity in many details of the calculated and observed spectra.

3. Conclusions

The mass outflow inevitably has to be compatible to the unification model, because the classical unification scheme [4] is very good argued and has even more confirmations last time. The main physical reason of the outflow unification is of course that the gas outflow in two opposite cones through the central hole in the OT. But the model of a real AGN has to take into account not only geometrical unification, but the evolution status of the AGN, its luminosity, the type of its hosting galaxy and other details.

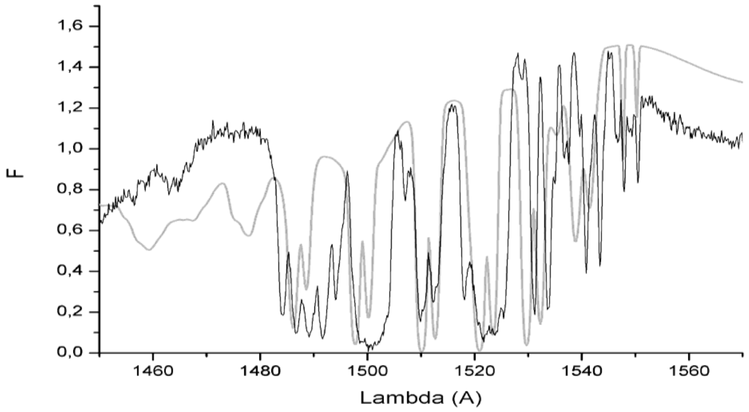

Fig. 2

The BAL QSOs present in about 15% of radio-quiet QSOs, but “intrinsic” fraction of BAL QSOs, taking into account the K-correction, is up to 22% [5]. The essentially larger part (~50%) of the Sy galaxies, showing both absorption lines and/or warm absorbers can be explained with larger covering factors, because of smaller velocity and the velocity gradient in this case. In BALQSO the hot gas seems to have mach higher temperature than in SyG.

Our model calculations of the two-phase outflows can explain absorption both in UV and X-ray bands, and this model is the single one which can provide the system of sharp absorptions in the objects with so-called “line-locking effect" in UV spectra.

References

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ҒАЛАМДАРДЫҢ АКТИВТІ ЯДРОЛАРЫНАН ЗАТ ӨТУІ

Э.Я. Вильковиский

Ғаламдардың активті ядроларының бірыңғайланған моделімен байланысқан ғаламдардың активті ядроларының зат өтуінің теориясының кейбір мәселері қысқаша талқыланады.

ИСТЕЧЕНИЕ ВЕЩЕСТВА ИЗ АКТИВНЫХ ЯДЕР ГАЛАКТИК

Э.Я. Вильковиский

Кратко обсуждаются некоторые проблемы теории истечения вещества Активных ядер галактик в связи с унифицированной моделью АЯГ.