Abstract

Broad emission lines, produced due to complex motion of illuminated material in a certain nuclear region of most active galaxies (known as the broad line region), are the most characteristic features of the optical/UV spectra of these sources. However, the dynamical nature of the broad line region (BLR) of active galaxies remains an open question, with observed evidence indicating a largely Keplerian motion alongside the possible traces of inflow or outflow. In this thesis, I present a comprehensive investigation into the BLR dynamics through analysing the efficiency of the dust driving mechanism, which is based on radiation pressure acting upon dust present at the surface layers of the accretion disk. Employing a non-hydrodynamical approach, I examine the behavior of dusty clouds leaving the disk surface and moving in the radiation field of the entire accretion disk, utilizing a realistic model for dust opacity and introducing a geometrical model as proxy for the local shielding. In Paper I, I expand the idea of the basic dynamical one-dimensional model of dust-driving mechanism responsible for the formation of broad line region in active galaxies, developed by Czerny & Hryniewicz (2011), known as FRADO (failed radiatively accelerated dusty outflow). We present the 3D numerical version of the model (2.5D due to azimuthal symmetry) in detail. I developed a non-hydrodynamical model with the single-cloud approach to the dynamics of BLR, but we carefully model the dust radiation pressure and the 3-D motion of a cloud. We showed that the radiation pressure exerted upon dusty clouds is potent enough to cause a dynamic outflow from the surface of accretion disk. I showed that the overall dynamics of BLR in this model is very complex, and the radial structure of BLR consists of zones of mostly failed winds, but also of an outflow from intermediate radii. The dynamics is strongly influenced by the Eddington ratio of the source, with high Eddington ratio sources showing a complex velocity field mentioned above and with significant vertical velocities relative to the local Keplerian rotation velocity of accretion disk, while lower Eddington ratio sources produce smaller vertical velocities and most of emission originates in proximity to the surface of accretion disk. Ultimately, the cloud dynamics serves as the principal determinant of the three-dimensional geometry of the BLR. In Paper II, we performed a preliminary test of the model using the observationally established radius-luminosity relation in AGNs. In the model the location of the BLR is not a parameter but it is determined mostly by the dust sublimation temperature. We showed that the model with different values of accretion rate and with adjusting the shielding effect can explain the observed location of the BLR comming from the most recent sample of sources with reverberation measured Hβ time-delays which includes the spread over the phenomenological relation with respect the Eddington ratio of the source. In Paper III, we tested the model by calculating the predicted spectral line generic profiles, using a large grid of results from the 2.5D FRADO numerical code. In this work, we have conducted an analysis of the impact of various parameters, including accretion rate, black hole mass, viewing angle, and dust-to-gas mass ratio, on the shape of the spectral line profiles. Our results demonstrated that the spectral line profiles are significantly influenced by the dust-to-gas mass ratio, which regulates the strength of the radiation pressure. We have also shown that the model can appropriately explain the shapes of the low-ionized broad emission lines, such as MgII and Hβ, observed in quasars mean spectrum. In this comparison, the only free parameter of the model was the dust-to-gas mass ratio, since the mass and Eddington ration were taken from the peaks of the quasar distribution for these parameters, and the viewing angle also represented the mean quasar viewing angle.