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Gas outflow in Seyfert galaxies: 3D radiative cooling hydrodynamical simulations

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Abstract. Accreting supermassive black holes and starburst regions influence their host galaxies through kinetic/radiative feedback processes. To better understand the gas evolution of a Seyfert galaxy, in this study we perform fully 3D hydrodynamical simulations with radiative cooling considering the presence of star formation regions, supernova feedback and small-scale (1 kpc) jet propagation in the central region of an active spiral galaxy. We compute the gas mass lost by the system and we conclude that a kpc-scale outflow is generally established only when a nuclear starburst region is coupled to a supermassive black hole jet.

Keywords. galaxies Seyfert, galaxies: starburst, galaxies: jet

1. Introduction

Outflows occur in most galaxies and transport energy and gas from the central regions. In complex systems where a starburst (SB) coexists with an active galactic nucleus (AGN), it is unclear whether the SB, the AGN, or both are driving the outflows. It is known that accreting supermassive black holes (SMBHs) influence their host galaxies through kinetic/radiative feedback processes, but many details of the specific feedback mechanisms remain unclear, and mainly in Seyfert galaxies, where the nuclear source emits an amount of energy comparable to that of the host galaxy, outflows may be consequence of the stellar activity, which therefore play a key role in the co-evolution of the system. To better understand the processes driving the nuclear gas evolution of a Seyfert galaxy, we perform fully 3D HD simulations at high resolution with radiative cooling, considering the presence of star formation regions, supernova (type I and II) feedback and small-scale (1 kpc) SMBH jet propagation in the central region of an active spiral galaxy.

2. The model and results

In our model we consider the central (kpc) region of a typical spiral (Seyfert) galaxy and set the initial conditions for the ISM following the procedure outlined in Melioli *et al.* (2013). We include the contribution of a bulge and a stellar disk, and then we set the ISM in equilibrium in the gravitational potential given by the summation of dark matter halo, bulge and disc contributions. The dark matter halo is assumed to follow the Navarro, Frenk & White (1996) profile, the gravitational potential of the stellar bulge is given by a Plummer distribution and finally, the gravitational potential of the gas disk is given by a Miyamoto & Nagai profile. In this study we assume also that the energy injected in the nuclear region comes by Type I and Type II SN explosions and/or by the jet produced by the SMBH in the center of the galaxy.

To simulate the evolution of the system described above, we employed a modified version of the Cartesian Godunov MHD code originally developed by G. Kowal (Kowal

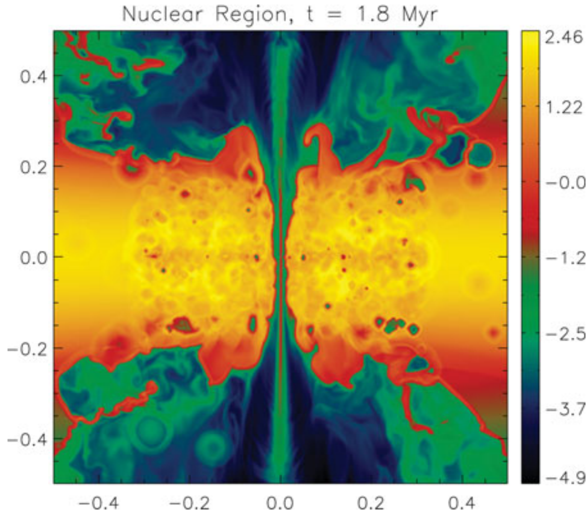

Figure 1. Edge-on logarithmic density distribution of the nuclear region of a Seyfert-like galaxy for the model *c*) (SNI+SB+JET), at t=1.8 Myr. Distances are given in kpc and density in c.g.s.

et al. 2007) which includes a parametrized cooling function in the energy equation that allows the gas to cool up to 100 K and which is calculated implicitly in each time step for each grid position. All the models are run with a maximum resolution of 1.9 pc per cell and the box has physical dimensions of 1×1×1 kpc in the x, y and z directions, respectively. The energy associated to each SN explosion is injected as thermal energy in a single cell, while the SMBH jet is injected in a single cell above and below the midplane disk, at the center of the system. For more details see Melioli et al. 2015 (in prep.).

We have run different models exploring a set of parameters able to describe the gas outflow as a function of the energy injected by a SB and/or by a SMBH jet. All the models were evolved along a time between 6 and 12 Myr. We here focus our attention mainly on 3 of them, where we considered a thick disk, with a column density of 5×10^{22} cm^{-3}, and the energy sources: *a*) SNI + JET; *b*) SNI + SB; *c*) SNI + SB + JET (Figure 1 shows the density distribution of this sample).

The main results we obtain can be summarized as follows: *i*) the presence of a jet does not affect the mass loss rate at the nuclear kpc region; *ii*) a gas outflow larger than 10 $M_\odot$ is possible only in presence of a nuclear ($r \leqslant 300$ pc) SB region with a SFR $\geqslant 1$ $M_\odot$ yr^{-1}; *iii*) the jet opens a channel through which hot gas can flow well above the plane of the galaxy; and *iv*) the observed high velocity signatures in the nuclear regions of Seyfert galaxies may be due to the interaction between the SB outflow and the collimated relativistic jet. In conclusion, we find that in Seyfert-like systems kpc-scale winds can be generally established only in presence of an intense nuclear SB.

References

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