DYNAMICAL MODELS OF EMISSION-LINE GAS IN RADIO GALAXIES

Tidal Interactions / Merger Scenarios

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1. Introduction

Extended emission-line regions (EELRs) in radio ellipticals are generally thought to trace gas acquired externally, *eg.* through interaction with a gas-rich disk galaxy (Athanassoula and Bosma 1985, Barnes and Hernquist 1992, Hernquist and Mihos 1995). We examine here the dynamical evolution of gas in mergers, focussing on the conditions required for collisions between streams of gas. We find that such collisions can occur over a relatively wide range of encounter geometries, producing large-velocity-amplitude kinematic signatures characteristic of those observed in EELRs. This is relevant to the formation of shocks, which can account for the ionization properties of EELRs (Koekemoer and Bicknell, this conference).

2. Model Results

The evolution of a gas-rich galaxy encountering a large spherical system was modelled using Smoothed Particle Hydrodynamics (SPH, Koekemoer and Bicknell 1995); the results presented here are for a spherical halo mass $M = 10^{12}\,\mathrm{M}_\odot$, velocity dispersion $\sigma = 250\,\mathrm{km\,s^{-1}}$, and core radius $r_c = 1\,\mathrm{kpc}$. A gas disk of mass $10^9\,\mathrm{M}_\odot$, radius 5 kpc and temperature 5000 K (warm, partially ionized ISM) was settled in an isothermal halo with $M = 5 \times 10^{10}\,\mathrm{M}_\odot$, $\sigma = 100\,\mathrm{km\,s^{-1}}$, $r_c = 0.5\,\mathrm{kpc}$. We investigated pericentric distances in the range $r_p = 2 - 10\,\mathrm{kpc}$, pericentric velocities v_p

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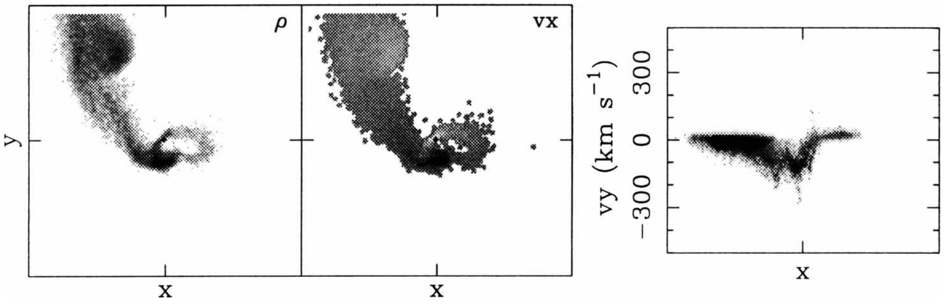

Figure 1. **Gas dynamic results as discussed in the text. Plotted are the surface density ρ, the x-velocity component v_x, and the line-of-sight y-velocity v_y projected along the y axis. The v_x greyscale corresponds to $-300 \rightarrow +350\,\mathrm{km\,s^{-1}}$ (white → black).**

up to unbound orbits (i.e. $990\,\mathrm{km\,s^{-1}}$ for $r_p = 2\,\mathrm{kpc}$), and disk inclinations θ of 0, 45 and 90° to the encounter plane. The volume was gridded into $240 \times 240 \times 80$ smoothing lengths (the smoothing length $h_s = 0.32\,\mathrm{kpc}$).

In Figure 1 we present gas kinematics for a simulation with $r_p = 5\,\mathrm{kpc}$, $v_p = 700\,\mathrm{km\,s^{-1}}$, $\theta = 45°$, at a time $1.5 \times 10^8\,\mathrm{yr}$ after the first pericentric passage. There is substantial interaction between material that has passed through the centre of the potential and that is still infalling; velocity shears of order $200 - 300\,\mathrm{km\,s^{-1}}$ are produced, and persist on timescales of $\sim 1 - 3 \times 10^8\,\mathrm{yr}$ after the initial pericentric passage, depending upon details of the encounter geometry. While the smoothing length is too large to resolve shock structures, shocks with velocities of this order can account for the observed ionization and energetics of the gas.

3. Conclusions

We find that collisions between streams of gas, with relative velocities corresponding to those observed ($\gtrsim 200\,\mathrm{km\,s^{-1}}$), can be produced in a wide range of merger encounter geometries and persist on timescales $\gtrsim 10^8\,\mathrm{yr}$, comparable to the AGN lifetime. The gas morphology changes significantly for different encounter parameters but its large-scale kinematics are affected primarily by the pericentric separation and the depth of the elliptical galaxy potential. Formation of shocks with these velocities can significantly affect the EELR ionization and energetics.

References

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