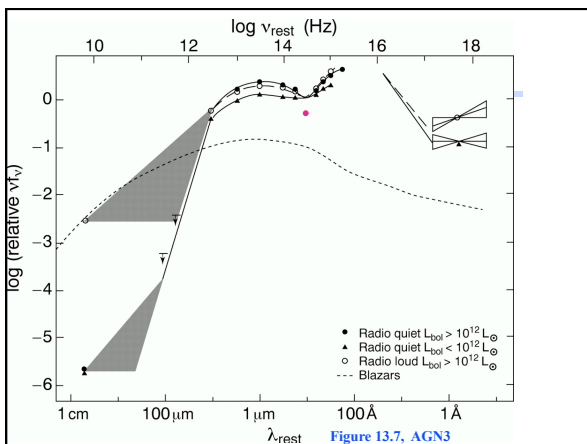
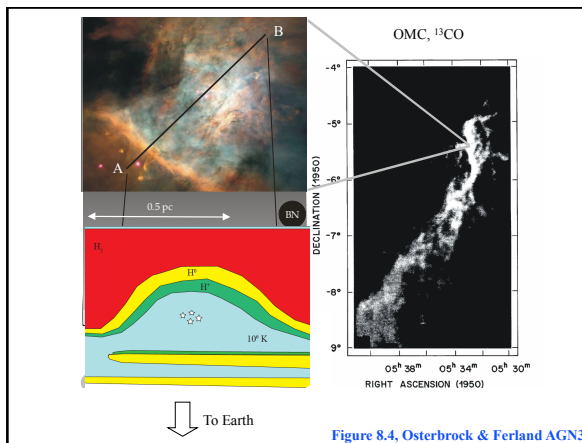


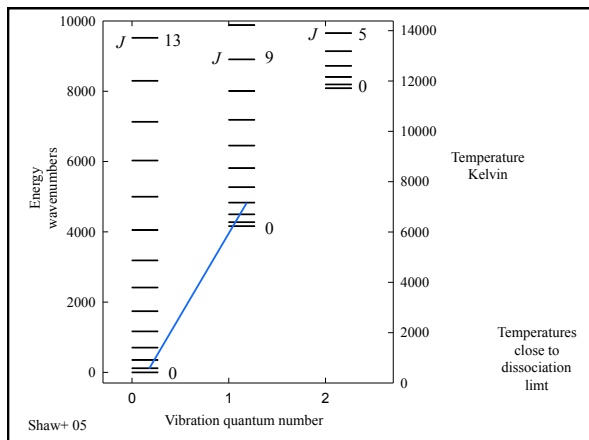
Spectrum of a non-equilibrium gas

- ◆ Treat microphysics in detail
- ◆ Energetic radiation & particles interact with gas
 - ionization
- ◆ Ejected electrons heats, excite & ionize gas
- ◆ Ionization drives chemistry
- ◆ Full spectrum predicted



Independent energy sources unlikely

Object	Heating erg cm ⁻² s ⁻¹	
	Radiative	Collisional
Earth	1 400 000	5.8
Supernova remnant	0.0028	7.9



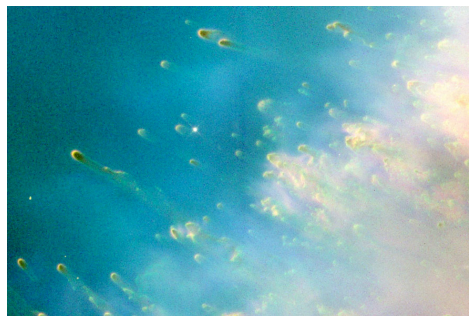
Four ways to produce strong ionic and H₂ emission

- ◆ Advection of molecular gas into hot ionized regions
- ◆ “extra heating” - heat deposition by shocks, dissipative MHD waves, etc
- ◆ Ionizing particles
- ◆ Very hard SED



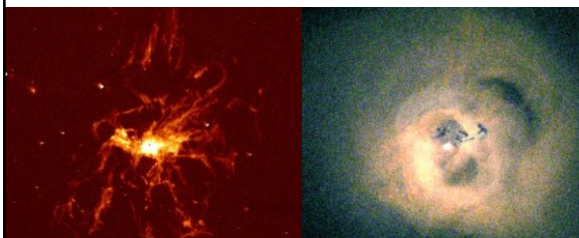
Advective flow of H₂ into H⁺ region

- ◆ Henney+ 07



Cool core cluster filaments

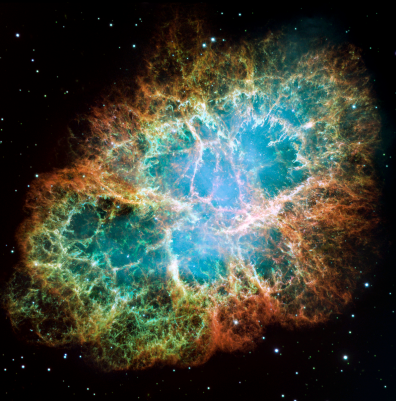
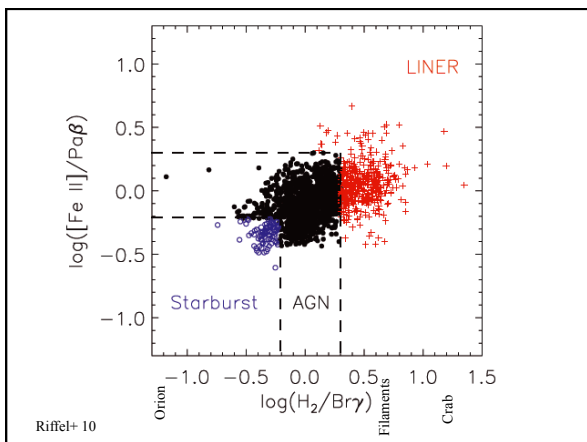
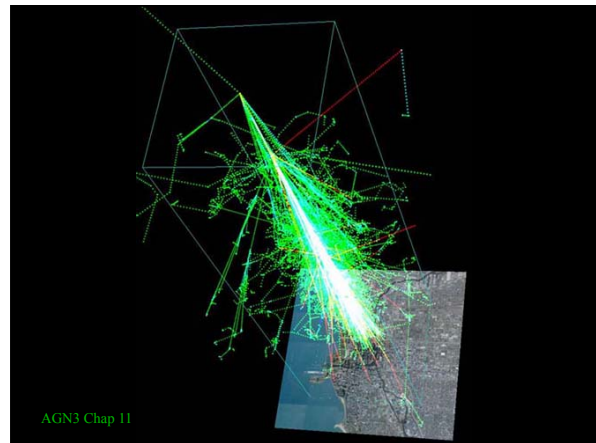
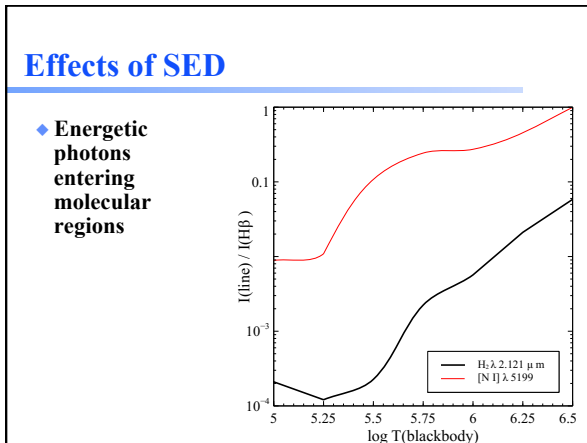
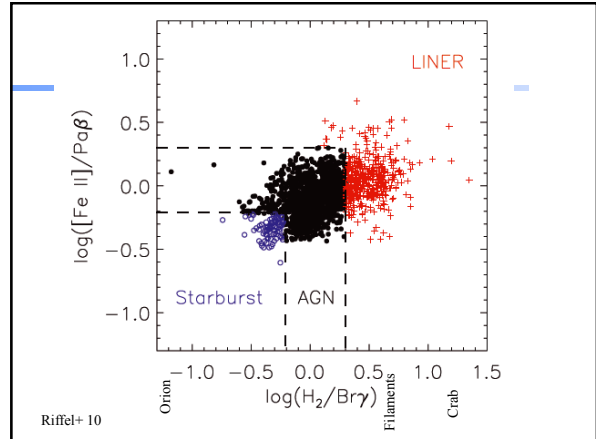
- ◆ Thermal particles from surrounding hot gas



– Johnstone+ 07, Ferland+ 08, 09, Fabian+ 11

The Crab

- ◆ Graham+ 90 hard photons or ionizing particles
- ◆ Lo+ 10, 11a 11b; H₂ is warm and abundant
- ◆ A photon-rich environment

Progress so far

- ◆ Helix H₂ results from rapid advective flow of H₂ into the H⁺ region (Henney+ 07)
- ◆ Cool-core cluster filaments are photon starved, with H₂ (and optical) emission due to penetrating ionizing particles (Ferland+ 09, Fabian+ 11)
- ◆ The Crab Nebula is photon-rich, and has abundant ionizing particles. Photons sufficient?? (Lo+ 10, 11a, 11b).
- ◆ Is the Starburst/AGN/LINER sequence the hardening of the 100-500 eV SED?