Multiphase Turbulence in Extragalactic Jet Cocoons

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The observations ("Alignment effect")
• Radio galaxies at redshift > 0.5 show associated optical emission: emission lines + rest frame blue continuum, correlations of many properties are evidence for the interaction
• Jet induced star formation has been suggested (confirmed by finding absorption lines in one case)
• Redshift ~1 objects are well studied – here we focus on these

Problems:
• Origin of the cold optical gas?
• How does the jet plasma interact with the cold gas?

Origin of the cold gas – some clues:
• Shock excitation (line ratios & widths) in small sources
  => jet somehow stirs up emission line clouds at least in smaller sources
• Photoionisation (cones, hidden quasar) dominates in larger sources, but emission is tied to the region close to the radio jet
  => line emitting clouds are not present independent of the jet, otherwise they would have been photoionised also before the jet reaches them
• Cross section of the jet beam is small and the surrounding cocoon would rather be backflowing
  => jets can hardly extract clouds from the galaxy
• Optical gas (~10^4 K) cooled from hotter phase (>10^6 K) surrounding the jet and the galaxy?
  => if some part of the shocked ambient gas would cool, all of it would soon be compressed to a thin, roughly spherical shell surrounding the source. Emission line clouds should be distributed throughout the interior, i.e. the optically emitting region should be much wider than observed
  => requires enhanced cooling in the cocoon (only)

A new mechanism: enhanced cooling due to turbulence

We simulated the non-linear evolution of the Kelvin-Helmholtz instability with a density ratio of 10,000, appropriate for the contact surface between jet cocoon and the shocked ambient medium. We added traces of cool and dense gas in clouds. The simulations are 2D hydrodynamic with cooling, performed with the Nirvana code.

Conclusions
The simulations show that all gas phases survive and interact intensively. We find a peak in the temperature distribution at 14,000 K caused by the balance of shock heating and radiative cooling. Turbulent energy equilibration and radiative leakage of the cold component causes a much reduced system cooling time and exponential cold mass condensation. The e-folding time is short enough to build up observed gas masses on the jet’s propagation timescale. Hence, the proposed mechanism may explain the origin of the optically emitting gas in radio galaxies, subject to 3D confirmation.