NUMERICAL SIMULATIONS OF THE FORMATION OF AGNS

J.P. SLEATH AND A.H. NELSON
Department of Physics and Astronomy
University of Wales, College of Cardiff
Cardiff ,CF2 3YB, U.K.

1. Motivation

- Many galaxies are seen to be undergoing a range of activity associated with an active nucleus. Whilst much effort goes into understanding the mechanisms involved, very few authors have considered how such AGNs might form.
- Our group has for many years being studying the formation of galaxies based on the collapse and fragmentation of self-gravitating gas dynamics (e.g. Williams, 1997).
- However, to produce jets (which we are using as a tracer of AGN activity) requires additional physics. Other work (e.g. Matsumoto et al., 1996) has shown that magnetic fields are important in the production of jets from accretion discs.
- Hence we have produced a fully self-gravitating, magnetohydrodynamic code with the aim of studying the formation of an AGN starting from the initial collapse of a primordial overdensity.

2. What sort of codes do we use?

- We begin our simulations with structures of size ~ 100 kpc yet need to resolve details with sizes of the order of parsecs. This is a huge range, and of course the density contrasts are even larger, $\sim 10^{15}$.
- Hence we require an extremely adaptable, flexible method. No grid-based technique could cope with the required dynamic range.
- However, TreeCode gravity (Hernquist, 1987) combined with Smoothed Particle Hydrodynamics (Monaghan, 1992) meets our requirements. It is a particle based method where the density of particles reflects the

Y. Sofue (ed.), The Central Regions of the Galaxy and Galaxies, 283-284.

https://doi.org/10.1017/S0074180900084941 Published online by Cambridge University Press

gas density in that region, thus giving maximal resolution where it is most needed.

- Moreover, magnetohydrodynamics can be incorporated in a natural way by solving for the dynamo equation and including the Lorentz reaction on the gas.

3. What are the results to date?

- We are able to produce realistic galaxies in terms of surface density profiles, dark matter distribution, spiral structure etc. The Lorentz force is generally small, and hence we would expect the main structural and morphological features to be determined by the self-gravitating gas-dynamics.
- The magnetic structure produced matches well with that observed for large spirals (Neininger et al. 1991; Neininger 1992) , with the field tracing very closely the spiral arms. Moreover, the calculated field saturates at values comparable to those observed.

4. What's next?

As yet no sign of jets. There are a number of avenues which we are pursuing:

- By increasing the transport of angular momentum we will be able to produce much higher densities in the central region. This could be achieved through galaxy interactions (currently our simulations focus on single objects) or other such mechanism.
- We are developing a new technique, known as Selected Lagrangian Weights (Nelson, Moore, 1994; Williams, Nelson, 1997). This will combine the best parts of SPH (i.e. adaptability and ease of use) with the best parts of a grid-based finite difference approach (higher resolution and accuracy).

References

Hernquist L., 1987, ApJS, 64, 715
Matsumoto R., Uchida Y., Hirose S., Shibata K., Hayashi M. R., Ferrari A., Bodo G., Norman C., 1996, ApJ, 461, 115
Monaghan J. J., 1992, Ann. Rev. Astron. Astrophys., 30, 543
Neininger N., 1992, A&A, 263, 30
Neininger N., Klein U., Beck R., Wielebinski R., 1991, Nature, 352, 781
Nelson A. H., Moore N. P., 1994, J. Italian Astronomical Society, 65, 1043
Williams P. R., 1997, Ph.D. thesis
Williams P. R., Nelson A. H., 1997, Proc. Astron. Soc. Pacific, in press