Rapport sur la thèse

SIMULATIONS COSMOLOGIQUES SUR SUPERORDINATEURS: LA SAGA P3M

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This thesis is concerned with the development of new numerical techniques for simulating the evolution of large-scale structure in the Universe under the action of gravity. The work is entirely technical in nature and is limited to a discussion of the numerical methods themselves; the thesis contains no application of these methods to the scientific problems for which they were designed.

The main text of the thesis is very well written – clear, concise and easy to read. I found only very minor technical or scientific errors, and almost no typographical errors. After a brief introduction, chapter 2 presents an excellent review of the development of the simulation technique (known as P3M) on which all the original work in the thesis is based. The author has clearly read and understood the literature of the field from the original papers of the 1970's up until the multiple developments of the last couple of years (some of which have already leap-frogged his own work).

Chapter 3 contains the first piece of original work in the thesis. This is an adaptation of the P3M algorithm to work on special purpose hardware (known as a GRAPE board) which can be attached to a normal work-station, giving it the effective power of a large parallel supercomputer. A number of difficult technical issues had to be resolved in order to make the GRAPE function correctly within an algorithm other than that for which it was designed. In addition this required some significant numerical creativity. The final code appears to work well and it is a pity that it appears so far to have been used rather little. This is undoubtedly a consequence of the fact that very few sites have so far purchased the GRAPE hardware.

Chapter 4 is a second original piece of work, this time an adaptation of the P3M algorithm to run on distributed memory parallel computers. This is a difficult and very substantial programming task which involves a substantial amount of redesign of the basic algorithm. The author has succeeded in creating a working code which runs efficiently and scales well in the weakly clustered regime (corresponding either to the early universe, or to the simulation of large volumes at relatively poor resolution). This is a significant achievement. Unfortunately, the most difficult task, designing an algorithm where the computation remains well-balanced when clustering becomes strong and the particle distribution is highly inhomogeneous, still remains to be done. As a result, although there is an interesting range of parameter space which can be studied with the current P4M,

this range is quite limited. A versatile and general message-passing code will require a lot more work.

The original work presented in this thesis is of high quality and is substantial - the design of innovative N-body algorithms at this level is a difficult task which requires strong numerical intuition and a close attention to detail, as well as "a good idea". It is a pity that the author did not have time to apply the codes himself because it is doubtful whether they will be much applied by others – the field is developing very fast on both hardware and software fronts. Despite this, I have no doubt that the thesis merits the award of a PhD, and so I recommend that it be accepted.

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Prof. S.D.M. White