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Dr. M Fulchignoni
Observatoire de Meudon, DAEC
5 Place Jules Janssen
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Dear Dr. Fulchignoni,

I have reviewed the submitted thesis of Philippe Pierre Brieu, and this letter is my report. The thesis reviews the nature of numerical simulations of self-gravitating systems for application to the problem of structure formation in the expanding Universe. This topic has been extremely active for the past decade, and developments continue as computers with differing architecture continue to evolve.

Continued study of structure formation in the Universe via simulation is a productive and essential tool which cosmologists have used to better understand how and when the observed structure came into existence, and which set of cosmological parameters best describes our observed Universe. Because the observed clustering has very large amplitude, alternative numerical methods such as analytical perturbation theory have limited applicability. Simulations are likely to continue their central role in future study of structure formation in the Universe.

Brieu's contribution has been in the domain of tool building, an essential component of the overall research effort, but a component which is unfortunately not given the credit it is due. Brieu's thesis first reviews well established simulation methods such as the Particle Mesh (PM) periodic code and the very elegant Particle-Particle supplement to the PM codes. Chapter 3 is the heart of the thesis, wherein Brieu describes the GRAPE (Gravity Pipe), a special N-body processor. This is a single board, made by a group in Japan, which can be connected to a desktop workstation, transforming a common, low-priced machine into a supercomputer. The GRAPE is a very limited device which can only compute one problem. Brieu deserves major accolades for his work (in conjunction with Frank Summers) to write a code that utilizes the GRAPE for cosmological N-body simulations. The major difficulty is that the cosmological simulations work best with periodic boundary conditions, while the native GRAPE architecture supports isolated boundary conditions. Brieu and Summers showed how to embed the GRAPE within the PPPM codes, and wrote a new code which is labeled P3MG3A. They demonstrate that this code has the performance of a Cray Supercomputer, a remarkable achievement for a low cost machine

that can sit on your desktop!

Brieu laments in his thesis that he did not have much opportunity to actually use his code for cosmological simulations. However, others have already used his code for a variety of purposes. We have a copy of the code at Berkeley and have used it extensively, although we have no results published yet. This is not a simple code; I believe Brieu has made a substantial and original contribution to astrophysics with this project. This code will see considerable use in the coming years, and the papers describing the construction of this code will be cited repeatedly.

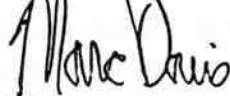
Chapter 4 of the thesis describes Brieu's attempts to overcome the limitations of the P3MG3A code, that is, limited resolution and operation on a scalar machine. We have been told repeatedly that the future lies with parallel computing, and Brieu bravely tried his hand at developing a parallelizable PPPM code, a very serious challenge. By Brieu's account, the results of this project to date have been disappointing. Sharing the computing load across the different processors and passing data between the processors is easy to state in principle but difficult to achieve in practise.

Brieu's tale of travail in the difficulty of constructing a code will be useful for the next generation of code builder to read. He feels he has sacrificed too much time on directions that led nowhere. His comment on the latest style of computing hardware, the distributed memory, distributed processor machines, is very poignant: "However, one factor that is often overlooked is that they do require an immense programming effort that needs careful planning. The human time invested in detailed programming may be disproportionate with respect to the gain in computing time".

Brieu is himself very unhappy with his thesis, since he feels he has been sacrificed to develop these codes, but has seen none of the benefits. Finding the balance between code construction and use is very similar to the problem of an instrument development and its use on a telescope. In astronomy, we have not given sufficient credit to the tool builders among us, on whom we are utterly dependent for scientific progress. It would have been better if Brieu had had the time to use his codes for some problem of current interest, but that does not diminish the substantial work he did accomplish.

I therefore feel that Brieu's efforts are sufficient for the work of a Doctoral thesis. The draft that I have read is a bit rough and I have previously communicated a number of corrections to Brieu.

Yours most sincerely,



Marc Davis

Professor of Astronomy and Physics