and the tests carried out with variable resolution according to the smoothing length in Sections 3 and 4. Results of isothermal collapses will be compared with analog data from other authors in Section 5.

2. Philosophy of the Code

The Numerical Technique and Comparison with Other Schemes

We use a Lagrangian description of a fluid by treating elements of fluid as finite-sized particles, the so-called smoothed particle hydrodynamics (SPH). This numerical technique was first introduced by Lucy [12], and since then well studied by Gingold and Monaghan [6, 7], Monaghan and Lattanzio [15]. It was shown to give very good results in many different applications [2, 11, 19].

Several methods can be used to simulate fluids dynamics: the Eulerian and Lagrangian schemes and intermediate ones as PIC (particle in cell) [8], which use a grid to facilitate the computations of the forces on the particles. However, the Lagrangian scheme is attractive and has important advantages over the other descriptions. First, it places the particles where the material is and should lead to a more economical calculation, especially if the code is vectorised, since the search of the neighbouring particles is the most penalizing for a scalar computation. Second, the main difficulty in the Eulerian description lies in the advective terms, while in the Lagrangian scheme the particles carry out the fluid quantities and the advective terms are intrinsically taken into account. Third, the PIC scheme requires interpolations, each time step, from grid to particles and from particles to grid, when the SPH code calculates the macroscopic quantities directly at the position of the fluid elements. Finally, owing to the variable smoothing length, the resolution is better in the high density regions.

Since the basic principles of the SPH method have been described in the references listed above, we will give only the main results.

Any macroscopic variable G can be evaluated as:

$$G(\mathbf{r}) = \sum_i m_i (G(\mathbf{r}_i)/\rho(\mathbf{r}_i))\, w(|\mathbf{r} - \mathbf{r}_i|, h_i), \tag{2.1}$$

where $\mathbf{r}_i$ are the vector positions of a set of N particles, w is the smoothing kernel, and h_i is the smoothing length; h_i is a function of $\mathbf{r}_i$ and then of the density. Also the derivatives of the fluid quantities are definable in terms of ∇w, so

$$\nabla(\rho G) = \sum_i m_i G(\mathbf{r}_i)\, \nabla w(|\mathbf{r} - \mathbf{r}_i|, h_i), \tag{2.2}$$

where ρ is the estimate of the density:

$$\rho(\mathbf{r}) = \sum_i m_i w(|\mathbf{r} - \mathbf{r}_i|, h_i). \tag{2.3}$$