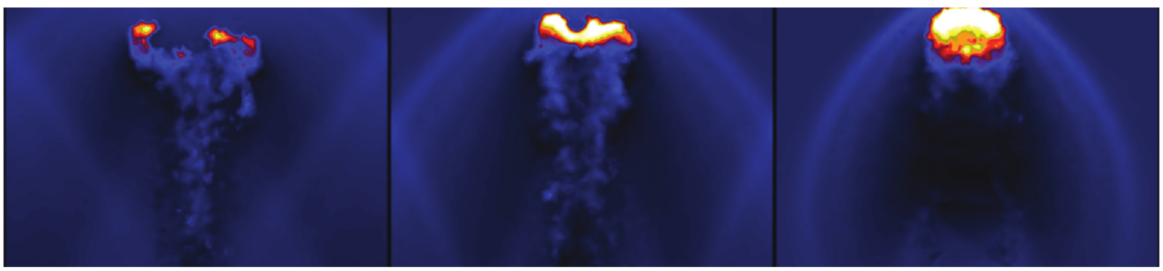
Research Proposal for a Master Thesis in Physics
Verifying the VPH scheme in Galaxy Formation

Sebastian Bustamante Jaramillo



Time evolution of a gas cloud in a supersonic wind using a `VPH` scheme. Taken from (Heß & Springel, 2010)

Contents

1 General Information

Information of the Student

Name	Sebastian Bustamante Jaramillo
Degree	B.Sc. in Physics, Universidad de Antioquia (2013)
E-mail 1	macsebas33 *at* gmail.com (personal)
E-mail 2	sebastian.bustamante *at* udea.edu.co (academic)

More detailed information of the applicant can be found here `http://goo.gl/BPZGzK`

Information of the Project

Title	**Verifying the VPH scheme in Galaxy Formation**
Field	Cosmology, Astrophysics, Physical Sciences
Advisor 1	Professor Juan Carlos Munoz-Cuartas. Universidad de Antioquia, Colombia.
University	Universidad de Antioquia, Master of Physics program
Time Frame	2 years

2 Abstract

3 Introduction

As we understand more deeply the physical processes involved in astrophysical phenomena, it becomes necessary to compute complex interactions of a ever increasing number of single components. Some prominent examples include simulations of the large-scale Universe, galaxy evolution, stellar interior, star formation and protoplanetary disk dynamics. A common aspect of these examples is that all of them can be regarded basically as a fluid mechanic problem.

Although the development of analytical approaches has demonstrated to be a valuable resource for studying these processes, their increasing complexity makes necessary to invoke numerical solutions as a more viable alternative. For this purpose, two different families of hydrodynamics solvers has been explored and widely used throughout the literature. First, a family of moving-mesh-based techniques (e.g. *Smoothed Particle Hydrodynamics* `SPH` (Monaghan, 1992), *Voronoi Particle Hydrodynamics* `VPH` (Heß & Springel, 2010)), and a second family of fixed-mesh-based techniques (e.g. *Adaptive Mesh Refinement* `AMR` (Berger & Colella, 1989)).

Due to the Lagrangian character of moving-mesh methods, techniques like `SPH` are easily implemented on a computer. Furthermore, as the physical system evolves, the mass particles naturally move into higher density regions, providing a self-adjusting spatial resolution. However, `SPH` has been shown to produce spurious suppression of fluid instabilities due to its kernel-based density estimator, making it unsuitable to model some of the dynamics accurately.

On the other hand, fixed-mesh methods like the `AMR` technique are more efficient for capturing shock dynamics. However, due to the conservative nature of the hydrodynamical equations, the fixed mesh causes a lack of Galilean invariance. Furthermore, the sampling of physical properties over the grid introduces spurious vorticity to the fluid, making this technique unsuitable for studying turbulent flows.

4 Objectives

General Objective

- Evaluating the performance of the `VPH` method

5 Theoretical Framework

6 Methodology

7 Expected Results

8 Scientific Impact

9 Schedule

Semester	Goals
First	• Identifying a set of existing `AREPO` simulations suitable for our succeeding studies. • Applying web finding schemes (T-web and V-web) to the simulations for quantifying structures in the gaseous cosmic web, i.e. voids, walls, filaments and clusters. • Evaluating properties of found structures at different redshifts.
Second	• Studying by mean of high resolution simulations the impact of the gaseous cosmic web on specific galaxy evolution processes.

8 Bibliography

Berger M. J., Colella P., 1989, Journal of Computational Physics, 82, 64

Heß S., Springel V., 2010, MNRAS, 406, 2289

Monaghan J. J., 1992, ARA&A, 30, 543