RADIATIVE TRANSFER IN GALAXIES

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A Thesis
Submitted to the School of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

Doctor of Philosophy

McMaster University

DOCTOR OF PHILOSOPHY (2015) McMaster University
(Physics and Astronomy) Hamilton, Ontario

TITLE: Radiative Transfer in Galaxy Formation

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NUMBER OF PAGES: 1

Abstract

In this thesis, we present a novel algorithm for computing the radiation field in astrophysical simulations.

Dedicated to...

Acknowledgements

Thank you to all that helped.

"Some sort of quote?"

Albert Einstein (1879-1955)

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The Numerical Method

In the absence of absorbing material, the problem of radiative transfer reduces down to that of gravity. As such, the tree-algorithm for calculating gravity can be used (**?**).

- A tree can be used to partition space.
- Each level of the tree holds finer partitions of the volume. See figure **??**
- Each node of the tree contains accumulated information about the tree below it (total mass, etc.).
- In order to calculate gravity on a particular leaf (bucket), you can interact with the moment of another cell (**??**).
- To decide what level of the tree to interact with, you can define an opening angle/radius, θ. If a cell is smaller than this opening angle (the distribution of matter inside the cell is contained within a small enough angle on the sky), the entire cell can be used in the force calculation. If not, you must consider the child nodes separately. See equation **??**.

- On average, the number of interactions a each particle will have is $\log N$, where N is the total number of particles. Thus, the force calculation for the whole simulation scales as $N \log N$. Note that lowering θ shifts the number of calculations that are approximated by large cells to smaller cells, and thus if θ is very small, the code approached scaling of order N^2.

- In the case of radiation, the math is very similar (See eq **??**). However, since radiation does not cancel like forces, the dipole moment does not disappear and a rougher approximation is possible (wording wrong, fix this).

- In this case, the interaction scales as $N_{\rm sink} \log N_{\rm source}$. However, assuming the full tree is still used, the tree-build still scales as $N \log N$.

3.1 Tree Data Structures

In order to understand the radiative transfer algorithm that we are presenting, it is important to understand tree data structures.

- Terminology: Node, root, child, parent, sibling, tree build, walk the tree, ascend the tree, descend the tree.

- In computer science, a tree is a hierarchical data structure. Typically the tree starts at a single point, usually called the root node, and branches out to many other "child" nodes.

- Each node in the tree stores some sort of data, and the relative location of the node in the tree indicates the relation of the data in the node to

the data in other nodes.

- GASOLINE uses a "k-d tree" for gravity. This is an example of a binary space-partitioning tree. Every node contains 2 children, and each node of the tree represents a particular volume of space. kd-Trees and octrees represent the majority of trees used in astrophysical simulations.

3.2 Building a Radiation Tree

- While the algorithm we present is general enough to work with any volume-filling tree, the following sections will introduce the algorithm as we have developed it. GASOLINE uses a k-d tree for its gravity solver, and as such, our version of the algorithm stuck with this tree type in order to make use of existing tools in the code base.

- The recursive pseudocode for the tree-build is presented below:

Chapter 4

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Appendix A

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