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FRACTAL AND MULTIFRACTAL ANALYSIS AS TOOLS TO CHARACTERIZE SUPERNOVAE AND MOLECULAR CLOUDS: SUBTITLE

Samuel Brenner[1]

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ABSTRACT

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1. INTRODUCTION

Many physical phenomena cannot be characterized by the idealizations of Euclidean geometry alone; they exhibit "roughness". That is, they have a detailed structure at any arbitrarily small size scale (Falconer 2003). The development of *fractal geometry* allows a mathematical treatment of the "roughness" inherent in the non-idealized phenomena of the real world. Multifractal analysis permits us to examine how those fractal characteristics themselves change with scale; in fact, they may even be fractal themselves. In this paper, we detail the application of fractal geometry to flame fronts in stars[2] and then analyze the multifractal characteristics of the cool molecular clouds involved in star formation.

1.1. *Fractal analysis of type 1a supernova flame fronts*

The accepted model for a type 1a supernova is a white dwarf that accumulates mass from a binary companion until it reaches a mass so large that the compression of the heavier elements in the core causes them to ignite and fuse, releasing more energy in the process. This deflagration results in a flame front that spreads rapidly throughout the star and causes the visible effects of supernova[3].

The surface of the expanding flame front can be dramatically affected by multiple types of turbulence. Landau & Lifshitz (1959) showed that the flame surface is subject to Landau-Derrieus instability in which the front is convoluted due to thermal expansion across the flame front. It is also widely established (See Kull (1991)) that Rayleigh-Taylor instability, in which a denser fluid pushes through a less-dense one under the influence of a gravitational field, can contort the deflagration front in a supernova.

These wrinkles in the surface of the flame front increase the front's effective surface area, and because the flame speed is proportional to the flame's surface area, the convolution of the surface can influence the speed with which the flame propagates through the star. Thus, characterizing the shape of the flame front can play a crucial part in characterizing the supernova as a whole.

These wrinkles in the surface of a turbulent front can be viewed within the framework of fractal geometry, as was proposed by Mandelbrot (1975) and further developed by Timmes, F. X. (1994). Furthermore, Timmes, F. X. (1994) showed that the effective speed v_{eff} of the flame front is given by

$$v_{eff} = v_{cond} \left(\frac{l_{min}}{l_{max}} \right)^{2-D} \tag{1}$$

where v_{cond} is the speed of the front through the material in the absence of turbulence, l_{min} is the minimum length scale[4] over which the turbulence takes place, l_{max} is the maximum length scale over which the turbulence takes place, and D is the fractal dimension of the flame front.

1.2. *Mutlfractal analysis of dense molecular clouds*

1.3. *Physical phenomena studied*

2. METHODS

World

3. RESULTS

Diving pretty deep here

4. ANALYSIS

Test

5. DISCUSSION

6. ACKNOWLEDGMENTS

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[1] Young Scholars Program, Florida State University samuel.e.brenner@gmail.com

[2] there's gotta be a better way to say this

[3] it does, right?

[4] I don't understand this well.