

# Amplitude Term Hunt

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## 1 INTRODUCTION

The purpose of this project is to design code that can help the user find specific sequence of terms in long expressions derived from string amplitudes.

String theory is considered the best possible candidate so far to constitute a theory of everything. Within the same formalism, all the fundamental forces, including gravity,<sup>1</sup> are quantised. When some specific limit behaviour is approached (i.e. the desired energetic scale to describe is low compared to some parameters<sup>2</sup> in the general definition) one can recover semi-classical description of well known fields (i.e Gravity, Electromagnetism, etc) .

One of those phenomenum we are interested in is the dynamics of the Universe.<sup>3</sup> The discipline in charge of this study from a stringy perspective is String Cosmology.

The main aim of String Cosmology is to take String Theory and perform a gentle transition to derive a semi-classical description of usual cosmology. In principle, this can be done at tree level (i.e. Just looking at the most relevant contributions of the interaction) but... not in the case we are interested in. Here, one needs to account for sub-leading corrections (i.e. not so relevant, yet not negligible contributions) to achieve one of the fundamental values of classical cosmology to be non 0.  $\Lambda$ , the cosmological constant. This constant is a fixed<sup>4</sup> positive value in Einstein's General Relativity equations to account for **the expansion of the Universe**.

These aforementioned corrections can be obtained from all possible interaction of different strings at sub-leading order. In the case we are interested in, it results to be around 7000 terms + all possible permutations for some values inside them. At this point, we need to ask a computer to identify which terms will contribute to our task, imposing a set of rules to localise them in such a long list. This is what these lines of code aim to do.

RETHINK AND IMPROVE INTRODUCTION. I GUESS I CAN DO IT BETTER

## 2 DESCRIPTION OF PROBLEM

The starting point is the file called *Loooong.csv* in the folder *Code*. This file contains all possible sub-leading contributions from string theory for a given interaction of specific set of strings.<sup>5</sup> From this long list, we are only interested on some terms with a specific given form as:

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<sup>1</sup>Gravity is the most elusive force to quantise. Plenty of problems arise when quantising from the classical description.

<sup>2</sup>The scale of the string  $l_s \rightarrow 0$ , which is analogous to not have enough energy to resolve how to atoms interact and we just see two little balls clashing.

<sup>3</sup>Classical cosmology is the disciple which studies this. It makes use of Einstein's General Relativity to describe the evolution of the Universe. Up to some extend, it gives the most accurate description we have of it.

<sup>4</sup>Or maybe not. This is hot topic research right now.

<sup>5</sup>Three closed strings, that can be mapped to six open ones.

$$\epsilon_1.\epsilon_2\epsilon_3.\epsilon_4\epsilon_5.\epsilon_6, \tag{1}$$

where  $\epsilon_i$  stands for the polarisation of the strings. Not only this form, but any other possible permutation of previous term is relevant for the aforementioned computation. Furthermore, permutation rules affecting  $\epsilon_i$  will affect other variables in the expression, which our code has to take account for.

### 3 METHOD

A rough sketch of the method to identify those terms is as follows:

1. Load the Amplitude expression into python from the *.csv* file.
2. Chop the string into different terms, separated by  $\pm$  signs.
3. Run a function that identifies the desired expression (1). If this substring is part of the term, store that term in a new list.
4. Perform permutations, accounting for the transformation rules of other variables.
5. Repeat from step 1.
6. Output all possible terms to another *.csv* file for further work on other programs.