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Qualitative study of a model with Rastall gravity

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Abstract

We consider the Rastall theory for the flat Friedmann–Robertson–Walker Universe filled with a perfect fluid that satisfies a linear equation of state. The corresponding dynamical system is a two dimensional system of polynomial differential equations depending on four parameters. We show that this differential system is always Darboux integrable. In order to study the global dynamics of this family of differential systems we classify all their non-topological equivalent phase portraits in the Poincaré disc and we obtain 16 different dynamical situations for our spacetime.

Keywords: Rastall gravity, first integral, global phase portrait, dynamical behaviour

1. Introduction

One characteristic of Eistein's theory of gravity is the conservation of the energy momentum tensor. So the total rest energy of a system is conserved however there is no experimental evidence for this. Rastall in 1972 proposed a modified theory of gravity where the matter source is described by the energy momentum tensor as in general relativity and also by the metric of the external space. Basically, Rastall suggests that the stress energy tensor of the source of the gravitational field should not conserved and so there is a coupling in a non minimal way between matter and geometry.

Rastall theory is considered as an extended theory of gravity, see for example [1] and provide answers to some questions relating to observational cosmology (see additionally [2, 3]) and quantum gravity [4, 5]. There is a kind of similarity between the particle creation process [6, 7] and Rastall theory since both of them do not respect the conservation of the energy

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