

Cosmic string passage through the Earth and consequent global earthquake

H. Motohashi · T. Suyama

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Abstract Effects invoked by the passage of the cosmic string through the Earth are investigated. The cosmic string induces global oscillations of the Earth whose amplitude and acceleration both linearly depend on the string line density. For the line density maximally allowed by the cosmic observations, the oscillations are perceivable even to human beings and may cause serious damages to the environment. On the other hand, the string with much smaller line density causes no visible effects. Yet, the sophisticated accelerograph is sensitive to a line density down to ten orders of magnitude smaller than the cosmologically relevant value.

Keywords Cosmic string · Earthquake

1 Introduction

Cosmic strings are line-like topological defects extending over the cosmological scales and are ubiquitous in field theories with spontaneous symmetry breaking (Jeannerot et al. 2003), or fundamental objects in string theory (Polchinski 2004). They might have been copiously produced in the early Universe and, if so, some of them are still present in the current Universe. Detection of the cosmic string has profound implications on high energy physics not probed by the terrestrial experiments. For instance, in the context

of the field theory, measurement of the line density of the string directly enables us to estimate the energy scale of the symmetry breaking. Various cosmological searches have been carried out to detect the cosmic strings both directly and indirectly. A straight cosmic string induces the gravitational lens effect and produce double images with exactly the same shapes. Cosmic strings also source the temperature anisotropies of the cosmic microwave background radiation (CMBR). Gravitational waves emitted from the cosmic strings modulate the pulsar timing and this fact has been used to look for the strings by the pulsar timing observations. So far, none of the observations has succeeded in detecting the cosmic string and only the upper bound on the string line density has been imposed. The latest CMBR observations by Planck satellite places the upper bound on the line density U as $U < U_{\max} \equiv 1.8 \times 10^{20}$ kg/m (Ade et al. 2013), assuming the Nambu-Goto string. Observations of the pulsar timing put the stronger upper bound as $U < 5.4 \times 10^{18}$ kg/m, although some assumptions about the string loop formation and gravitational wave emission are made to derive this bound (van Haasteren et al. 2011). There are some inflationary models in which the cosmic strings with line density as large as U_{\max} do not conflict with the pulsar timing observations (Kamada et al. 2012). Hereafter, we will assume that U_{\max} is the maximally allowed value of the string line density. Improvement of the sensitivity of any measurement in future has potential to detect the cosmic string.

In this paper, instead of studying the cosmological implications of the cosmic string, we consider passage of the cosmic string through the Earth and investigate the resultant distortion of the Earth in order to determine what kind of signatures are expected to detect the string (Fig. 1). Similar investigations are performed in Khriplovich et al. (2008a, 2008b), where the passage of the primordial black hole

H. Motohashi
Yukawa Institute for Theoretical Physics, Kyoto University,
Kyoto 606-8502, Japan

H. Motohashi (✉) · T. Suyama
Research Center for the Early Universe (RESCEU), Graduate
School of Science, The University of Tokyo, Tokyo 113-0033,
Japan
e-mail: motohashi@resceu.s.u-tokyo.ac.jp