Physics Letters B 810 (2020) 135838

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Anomalous $U(1)$ gauge bosons as light dark matter in string theory

Luis A. Anchordoqui [a,b,c], Ignatios Antoniadis [d,e], Karim Benakli [d,*], Dieter Lüst [f,g]

[a] Department of Physics and Astronomy, Lehman College, City University of New York, NY 10468, USA
[b] Department of Physics, Graduate Center, City University of New York, NY 10016, USA
[c] Department of Astrophysics, American Museum of Natural History, NY 10024, USA
[d] Laboratoire de Physique Théorique et Hautes Énergies - LPTHE Sorbonne Université, CNRS, 4 Place Jussieu, 75005 Paris, France
[e] Albert Einstein Center, Institute for Theoretical Physics, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland
[f] Max–Planck–Institut für Physik, Werner–Heisenberg–Institut, 80805 München, Germany
[g] Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, 80333 München, Germany

ARTICLE INFO

Article history:
Received 4 August 2020
Received in revised form 27 September 2020
Accepted 29 September 2020
Available online 2 October 2020
Editor: A. Ringwald

ABSTRACT

Present experiments are sensitive to very weakly coupled extra gauge symmetries which motivates further investigation of their appearance in string theory compactifications and subsequent properties. We consider extensions of the standard model based on open strings ending on D-branes, with gauge bosons due to strings attached to stacks of D-branes and chiral matter due to strings stretching between intersecting D-branes. Assuming that the fundamental string mass scale saturates the current LHC limit and that the theory is weakly coupled, we show that (anomalous) $U(1)$ gauge bosons which propagate into the bulk are compelling light dark matter candidates. We comment on the possible relevance of the $U(1)$ gauge bosons, which are universal in intersecting D-brane models, to the observed 3σ excess in XENON1T.

1. Introduction

The primary objective of the High Energy Physics (HEP) program is to find and understand what physics may lie beyond the Standard $SU(3)_C \otimes SU(2)_L \otimes U(1)_Y$ Model (SM), as well as its connections to gravity and to the hidden sector of particle dark matter (DM). This objective is pursued in several distinct ways. In this Letter, we explore one possible pathway to join the vertices of the HEP triangle using string compactifications with large extra dimensions [1], where sets of D-branes lead to chiral gauge sectors close to the SM [2,3].

D-branes provide a nice and simple realization of non-abelian gauge symmetry in string theory. A stack of N identical parallel

String compactifications could leave characteristic footprints at particle colliders:

- the emergence of Regge recurrences at parton collision energies $\sqrt{s} \sim$ string mass scale $\equiv M_s = 1/\sqrt{\alpha'}$ [4–6];
- the presence of one or more additional $U(1)$ gauge symmetries, beyond the $U(1)_Y$ of the SM [7–9].

Herein we argue that the (anomalous) $U(1)$ gauge bosons that do not partake in the hypercharge combination could become compelling dark matter candidates. Indeed, as noted elsewhere [10] these gauge fields could live in the bulk and the four-dimensional $U(1)$ gauge coupling would become infinitesimally small in low