Accepted Manuscript

Free electron laser and fundamental physics

Giuseppe Dattoli, Federico Nguyen

PII: S0146-6410(18)30004-8
DOI: https://doi.org/10.1016/j.ppnp.2018.01.004
Reference: JPPNP 3659

To appear in: *Progress in Particle and Nuclear Physics*

Please cite this article as: G. Dattoli, F. Nguyen, Free electron laser and fundamental physics, *Progress in Particle and Nuclear Physics* (2018), https://doi.org/10.1016/j.ppnp.2018.01.004

Free Electron Laser and Fundamental Physics

Giuseppe Dattoli[a], Federico Nguyen[a]

[a] *ENEA–Fusion and Nuclear Safety Department, C.R. Frascati, Via E. Fermi 45 – 00044 Frascati (Roma), Italy*

Abstract

This review paper is devoted to the understanding of free-electron lasers (FEL) as devices for fundamental physics (FP) studies. After clarifying what FP stands for, we select some aspects of the FEL physics which can be viewed as fundamental. Furthermore, we discuss the perspective uses of the FEL in FP experiments. Regarding the FP aspects of the FEL, we analyze the quantum electrodynamics (QED) nature of the underlying laser mechanism. We look for the truly quantum signature in a process whose phenomenology is dominated by classical effects. As to the use of FEL as a tool for FP experiments we discuss the realization of a device dedicated to the study of non-linear effects in QED such as photon-photon scattering and shining-through-the-wall experiments planned to search for dark matter candidates like axions.

Keywords: Free Electron Laser, Photon Interactions, Two Photon Physics, Axion Photon Coupling

1. Introduction

The free-electron laser (FEL) radiation is becoming an increasingly popular tool to study the interaction of "light" with "matter". We have used quotes to mention light and matter because we will refer to these terms in a broader sense. Light stands *e.g.* for electromagnetic radiation, whereas matter is anything with mass including dark matter. We will further extend the concept of light by including *e.g.* static fields and by discussing the equivalence between emission by undulator magnet and the Compton backscattering.

FEL is based on a mechanism which is a paradigmatic example of fundamental physics (FP) processes. It is indeed accounted for in terms of the interaction between the archetypes of fundamental particles in quantum electrodynamics (QED), namely photons and electrons.

Email addresses: giuseppe.dattoli@enea.it (Giuseppe Dattoli), federico.nguyen@enea.it (Federico Nguyen)