UMEÅ UNIVERSITET

Modelling and analyzing strong-field effects in quantum plasma

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt försvar i NAT.D 450, Naturvetarhuset torsdagen 2023-06-01 kl. 13:00.
Avhandlingen kommer att försvaras på engelska.

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Department of Physics

Organization
Umeå University
Department of Physics

Document type
Doctoral thesis

Date of publication
11 May 2023

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Title
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Abstract

Under the extreme conditions that can be found around dense stars and in the accretion discs of black holes, several strong-field quantum phenomena dominate the dynamics of the plasma. This includes the creation of matter and anti-matter from the vacuum (Schwinger mechanism), radiation reaction and Landau quantization. Some of these strong field phenomena were presented theoretically a century ago but have never been verified in experiments due to the difficulty of creating the required extreme conditions in the lab. However, with the development of laser facilities in the past decades, it will be possible to observe several extreme physical phenomena in the near future. To conduct experiments on these extreme phenomena, theoretical simulations need to be constructed as a guide for optimizing experiments.

This thesis is concerned with developing and analyzing strong field phenomena in kinetic plasma models. The focus is to extend current kinetic models to include several physical phenomena that are relevant to future experiments on laser-plasma interaction. In particular, a kinetic theory based on the Wigner transformation of the Dirac equation has been analyzed in different regimes. This kinetic model is used to study the plasma dynamics at the Schwinger limit, where collective plasma effects and several quantum processes are studied.

Keywords
Laser; Plasma, Quantum Electrodynamics; Schwinger mechanisms; Radiation reaction; Spin; Kinetic theory.

Language
English

ISBN
978-91-8070-067-2 (print)
978-91-8070-068-9 (PDF)

Number of pages
69+ 7 papers