Theoretical Particle Physics at the University of Graz

Current and (near-) future research topics

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Graz Center of Physics

Graz Center of Physics

Yesterday afternoon, outside my office window:

Graz Center of Physics

Official start of construction: June 4, 2024

Scheduled completion: 2030

Graz Center of Physics

- Physics of TU Graz and University of Graz
- 600 staff, 1700 students
- Theoretical Particle Physics:
  one of (appr.) seven research groups

Research Topics

NB: Alphabetical order

Research Topics

Strongly Interacting Fields (Reinhard Alkofer):[1]

- Light and heavy mesons from relativistic bound state equations
  - production mechanisms and decays (incl. exotic hybrids)
  - time-like form factors
- Unquenched QCD vertex functions
  - chiral symmetry breaking interactions
- Electron-positron pair production in ultra-strong laser fields
  - time-dependence of particle production by fields
  - experimental verification (dynamically assisted Schwinger effect)
- Ultraviolet completion of the Standard Model
  - Renormalization Group equations incl. parameterized new physics
- Dirac fermions and torsion in Einstein-Cartan gravity
  - unimodular version of Einstein-Cartan gravity
  - the quark condensates' impact on the cosmological constant

[1] until 09/2025;
succession (particle physics with astrophysics applications) starts 10/2025

Research Topics

Hadron physics (Gernot Eichmann):

- Tetraquark spectra
  - Hidden charm (2402.12830)
  - Open charm
- Deuteron
  - Solution of relativistic bound state equation with quark d.o.f.
  - Importance of quark, diquark, pion and sigma exchange
  - 20% *p*-waves: deuteron constituted by relativistic Dirac fermions
- Hadron structure
  - test of novel method based on analytic continuation (scalar model)
  - PDFs and TMDs via analytic continuation
- Pentaquarks
  - Solve relativistic 5-body bound state equations based on 2-, 3-, and 4-body solutions in a scalar model
  - Application to QCD and calculation of respective spectra; relevant experiment LHCb

Research Topics

Beyond the Standard Model (Suchita Kulkarni):

- Dark matter
  - studies of dark matter emerging from new strongly interacting theories (as a part of the FG1 research group)
  - focus on collider strategies

- Heavy neutral leptons
  - studies of current constraints on non-minimal heavy neutral lepton models in combination with prospects at future colliders.

Research Topics

Gauge invariance and observables (Axel Maas):

- Lepton colliders (FCCee or similar, muon collider)
  - New subleading effects from manifest gauge invariance (2305.01960)
  - Threshold corrections of order few percent (2204.02756)
  - Substantial corrections (10% +) at TeV scales (2212.08470)
- Gravitational physics
  - LISA/Dark matter searches
  - Quantum gravity simulations (CDT)
  - Relevant possibly to cosmology and dark matter (2202.05117, 1908.02140)
- BSM physics
  - Collider searches
  - Consistent scenarios for GUTs (2305.01960)
  - SUSY restoration (2305.01960)

Research Topics

Event generators (Simon Plätzer):

- Hadron colliders
  - high densities, high multiplicity pp
  - soft QCD as background to jets and EW processes
  - small x, heavy ion collisions
- Lepton colliders
  - focus QCD&EW: complex final states, jets, IR sensitive observables
  - role of fundamental parameters, hadronization corrections
- Particle reactions beyond colliders
  - particle reactions in astrophysical context (Cosmic Rays, including acceleration and transport)
  - neutrino physics
- Gravitational physics
  - graviton amplitudes and resummation, definition of external states
- Simulation for QFT as a tool
  - IR structure of gauge theory amplitudes for many legs and loops
  - algorithmic aspects of amplitude and lattice simulations

Research Topics

Lattice QCD (Denés Sexty)[2]:

- QCD phase diagram of QCD
  in particular at high densities
  - high temperature (e.g. FAIR)
  - low temperature (neutron stars).
- Time evolution and real time quantities in QFT
  - transport coefficients
  - tunneling rates
  - ...
  - Relevant experiments: heavy ion collisions (e.g. ATLAS).

[2] Christof Gattringer on leave of absence