Particle physics - theory

at University of Zagreb, Faculty of Science

(presented by Krešimir Kumerički)
Physics Department

Theoretical Physics Division of Particles and Fields

Two research groups:

1. Gravitation and black holes  (→ see next presentation by M. Cvitan)
   - 3 seniors (+ 1 emeritus)
   - 1 PhD student

2. Phenomenology of elementary particles and fields
   - 5 seniors (+ 1 emeritus)
   - 1 postdoc
   - 2 PhD students
Beyond Standard Model 1/2

- (Amon Ilakovac, Marija Mađor-Božinović, Hermés René Bélusca Maïto)
- Building models of new physics: **supersymmetry**
- Phenomenology: looking for violations of symmetries
  - lepton number conservation
  - anomalous electric and magnetic dipole moments
- skills in loop calculations, automatic amplitude calculations, renormalization group
- Example paper:
  - *Lepton Dipole Moments in Supersymmetric Low-Scale Seesaw Models*
  - Also: contribution to Working Group 3 of the CERN Workshop “Flavor in the era of the LHC”
Beyond Standard Model 2/2

- (Krešimir Kumerički, Ivica Picek)
- Building models of new physics: neutrino masses
- Phenomenology of new particles within the reach of LHC
- Example paper:
  - Renormalizable SU(5) Completions of a Zee-type Neutrino Mass Model,

New proposed particles: E, Δ, h
- explaining small neutrino mass and making GUT possible
Extending Higgs sector with additional scalars

- one-loop and three-loop radiative neutrino mass models
- study of perturbativity and vacuum stability, absence of Landau poles
- detailed LHC phenomenology

<table>
<thead>
<tr>
<th>Model</th>
<th>$J^{CP}_H$</th>
<th>$\Gamma_H$ (GeV)</th>
<th>Production</th>
<th>Landau Pole</th>
<th>$Br_{WW}$</th>
<th>$Br_{\gamma\gamma}$</th>
<th>$Br_{Z\gamma}$</th>
<th>$Br_{ZZ}$</th>
<th>$Br_{t\bar{t}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-loop</td>
<td>0$^{++}$</td>
<td>3</td>
<td>$\gamma\gamma$-fusion</td>
<td>Absent</td>
<td>64%</td>
<td>7%</td>
<td>6%</td>
<td>23%</td>
<td>–</td>
</tr>
<tr>
<td>3-loop</td>
<td>0$^{++}$</td>
<td>44</td>
<td>$gg$-fusion</td>
<td>$10^6$ GeV</td>
<td>26%</td>
<td>1%</td>
<td>4%</td>
<td>7%</td>
<td>61%</td>
</tr>
</tbody>
</table>

Example paper:
Studies in quantum chromodynamics 1/3

- (Marija Čuić, Krešimir Kumerički)
- Generalized parton distributions - models and phenomenology
- goal: 3D partonic picture of the nucleon
- perturbative QCD + neural networks = pressure in the nucleon

Example paper:

Studies in quantum chromodynamics 2/3

- (Davor Horvatić, Dubravko Klabučar)
- Non-perturbative features of QCD: confinement and chiral symmetry breaking
- Dyson-Schwinger model of non-perturbative QCD
- Restoration of symmetries at high temperatures

- Example paper:
  - $\eta'$ and $\eta$ mesons at high $T$ when the $U_A(1)$ and chiral symmetry breaking are tied, D. Horvatić, D. Kekez, D. Klabučar, Phys. Rev. D99 (2019) 014007
3/3: Color Glass Condensate at RHIC, LHC and EIC

- (Sanjin Benić)
- Inclusive photon production - predictions for pp and pA at the LHC
- polarized pA at RHIC: interplay between twist-3 PDFs/FFs and CGC gluons

S. Benić, Y. Hatta, PRD 99 (2019) 094012

- Hiring postdoc: fall 2020! SAT-PHENO (CSF (HRZZ) startup project)