Theoretical particle physics in the Czech Republic

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Contents

1) Institutions & people
2) Current research themes
3) Sample publications
4) Some scientometric data
5) Education, Ph.D. training
6) International collaboration
7) Funding
8) Summary & outlook
### Institutions & people

<table>
<thead>
<tr>
<th>Institution</th>
<th># people with Ph.D. in particle theory</th>
<th># Ph.D. students in particle theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles University, Prague</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Institute of Physics ASCR, Prague</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Czech Technical University, Prague</td>
<td>5</td>
<td>2</td>
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<tr>
<td>Nuclear Physics Institute, Řež (near Prague)</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Masaryk University, Brno</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Silesian University, Opava</td>
<td>1</td>
<td>2</td>
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At present, about 20 Ph.D.’s active in the field. Others migrated to experimental high energy physics, mathematical physics unrelated to particle physics, computing, and/or outreach activities. Among the active particle theorists, 3 – 4 are already in their retirement age.
Current research themes

Charles University:
Electroweak theory, effective Lagrangians (in particular, chiral perturbation theory for mesons), methods in field theory

Institute of Physics, ASCR:
QCD theory and phenomenology, symmetries in field theory, phenomenology of elastic hadron scattering

Czech Technical University:
Mathematical physics close to string theory (sigma models in curved backgrounds and their symmetries, etc.)

Nuclear Physics Institute, ASCR:
Electroweak symmetry breaking, nonperturbative aspects of QFT, color superconductivity in QCD, spontaneously broken symmetries, hadron phenomenology

Masaryk University (Brno):
String theory, quantum gravity & cosmology, gauge field theory

Silesian University (Opava):
Hadron phenomenology
Tests of naturalness of the coupling constants in ChPT at order $p^6$
K. Kampf (Charles U.), B. Moussalam (Orsay, IPN)

The Dalitz decay $\pi^0 \rightarrow e^+ e^- \gamma$ revisited
K. Kampf (Charles U.), M. Knecht (CPT Marseille), J. Novotný (Charles U.)

Possible non-decoupling effects of heavy Higgs bosons
in $e^+ e^- \rightarrow W^+ W^-$ within THDM
M. Malinský (Charles U.), J. Hořejší (Charles U.)

Fundamentals of electroweak theory
J. Hořejší (Charles U.)

On the space-time symmetries of noncommutative gauge theories
The implications of final L3 measurement of $\sigma_{\text{tot}} (\gamma\gamma \rightarrow b \text{ anti } b)$
J. Chýla (Prague, Inst. Phys.)

On the infrared freezing of perturbative QCD in the Minkowskian region
I. Caprini (Bucharest, IFIN-HH), J. Fischer (Prague, Inst. Phys.)

Relativistic Coulomb problem for particles with arbitrary half-integer spin.

Massive nonlinear sigma models and BPS domain walls
in harmonic superspace
M. Arai (Prague, Inst. Phys.), E. Ivanov (Dubna, JINR), J. Niederle (Prague, Inst. Phys.)

Interference between Coulomb and hadronic scattering in elastic high-energy nucleon collisions
V. Kundrát (Prague, Inst. Phys.), M. Lokajíček (Prague, Inst. Phys.)

Proton spin structure and valence quarks
P. Závada (Prague, Inst. Phys.)
Flat coordinates and dilaton fields for three-dimensional conformal sigma models  
L. Hlavatý, M. Turek (Prague, Tech. U.)  

Poisson-Lie T plurality of three-dimensional conformally invariant sigma models  

Dynamical fermion mass generation by a strong Yukawa interaction  

Anisotropic admixture in color superconducting quark matter  
M. Buballa (Darmstadt, GSI), J. Hošek (Rez, Nucl. Phys. Inst.), M. Oertel (Lyon, IPN)  

Goldstone boson counting in linear sigma models with chemical potential  
T. Brauner (Rez, Nucl. Phys. Inst.)  

Minkowski space solution of Dyson-Schwinger equations in momentum subtraction scheme  
V. Šauli (Rez, Nucl. Phys. Inst.)  
Ricci-flat supertwistor spaces
U. Lindstrom (Uppsala U.), M. Roček (SUNY, Stony Brook), R. von Unge (Masaryk U., Brno)

Charged black holes in compactified spacetimes
M. Karlovini, R. von Unge (Masaryk U., Brno)

On generalized gauge-fixing in the field-antifield formalism
I. A. Batalin (Lebedev Inst.), K. Bering (Masaryk U., Brno),
P. H. Damgaard (Bohr Inst.)

Factor ordering in standard quantum cosmology
R. Šteigl, F. Hinterleitner (Masaryk U., Brno)
Class. Quant. Grav. 23 (2006) 3879.

An alternative parametrization of the pion form-factor and the mass and width of $\rho(770)$.
P. Lichard (Silesian U., Opava), M. Vojík (Silesian U., Opava)
Some scientometric data

Current production rate: About 30 theoretical papers per year, if one counts only those with at least one Czech institution at the list of authors’ addresses. This represents a moderate increase in comparison with e.g. the early 1990s. Total number of such “Czech” papers that have appeared since 1980 till now is roughly 450.

Citation impact: Among those 450 items there is

1 paper with more than 250 citations
7 papers with 100 – 249 citations
10 papers with 50 – 99 citations

and more than 50 papers with 10 – 49 citations

(the above classification borrowed from SPIRES)
In this respect, the situation is certainly better than e.g. in 2000, partly due to new successful papers, and also simply to the arrow of time.
Education, Ph.D. training

Specialized Ph.D. training involves, among other things, summer schools and “intensive courses”

Schools:

E. g. the Central European School in Particle Physics (formerly “Triangle Graduate School”). Typically 30 – 40 participants mostly from “extended Central Europe”, the tradition goes back to the early 1990s. In September 2007, CESPP to be held at Charles U. in Prague.

Another example: the Indian-Summer School on nuclear/particle physics, organized regularly by NPI Řež (in recent years, particle physics themes prevailed).

Furthemore, the Dubna-CERN European School in High Energy Physics to be held in Czech Republic (Třešt’) in 2007, two Czechs (young postdocs) will act as discussion leaders.
Intensive courses:


3 – 4 intensive courses on advanced topics organized per year (one speaker, about 20 Ph.D. students, duration typically 2 weeks). One such course (Renormalization theory, by C. Becchi, Genova) to be held here in Prague in June 2007.
International collaboration

Long term institutional scientific collaboration with CERN, JINR Dubna, and in recent years also with ECT* Trento (both nuclear & particle physics). These contacts contribute to Ph.D. training as well.

The „chiral group“ at IPNP, Charles U. belongs to the EU network FlaviaNet (formerly Euridice and EuroDaphne) as a „subnode“.

Within this, regular collaboration with IPN Orsay and CPT Marseille.

As mentioned before, there is the newly founded „Joint Programme of Doctoral Studies in Theoretical Physics“.

Within this, institutional collaboration with universities in „extended Central Europe“ (Budapest, ..., Trieste, Vienna, Zagreb).

Of course, on the individual basis, there are many more international contacts, as documented e.g. by the list of sample publications shown before.
Funding

Apart from the long-term institutional research projects financed by the Ministry of Education or the Academy of Sciences, a very substantial additional source is provided by the Center for Particle Physics, a complex project of the Czech Ministry of Education that has started in 2000. Institutions involved at present are Charles University, Institute of Physics ASCR and Czech Technical University. It covers both experimental and theoretical particle physics and the level of funding has been rather generous, especially in its start-up phase 2000 – 2004.

Other supplementary sources are provided by some particular grants of the Ministry of Education, Czech Science Foundation (GACR), as well as some smaller grant agencies run by Czech universities and ASCR.

In my opinion, the present financial support for theoretical particle physics (in fact, for the particle physics as a whole) from public sources in CR is good.
Summary & outlook

For obvious reasons, the general situation in the field seems to be better than it was e.g. in the late 1980s.

On the other hand, some important topics of modern particle theory are still not pursued actively at domestic institutions (for example, phenomenology of models going far beyond SM, etc.).

However, a gradual improvement may be in sight during the next decade or so: Since a chance for getting a permanent position at a Czech institution is better than in the Western Europe or U.S., qualified people from other EU countries are coming, and also some of our former graduates plan to return back home (after several postdoc stays abroad), bringing new research themes.

Thus, in my opinion, the prospects of theoretical particle physics in CR are not bad.