

MTA Wigner FK, RMI, Femtoscopy Research Group

T. Csörgő, A. Ster, F. J. Nemes (EKE), G. Kasza[#] (EKE), D. Kincses[#] (ELTE), T. Novák (EKE), I. Szanyi (ELTE)

The Femtoscopy Research Group is actively participating both in **theoretical and experimental research**. The **PHENIX** experiment at the RHIC accelerator is in the data analysis phase at Brookhaven National Laboratory. One of our PHENIX result, published online in Nature Physics already in December 2018, was selected as the cover page story of Nature Physics in March 2020. The **TOTEM** experiment at Large Hadron Collider (LHC) at CERN continued its preparations for Run-3 and its data analysis programme as well. During 2018, we have achieved important theoretical results, as well as experimental results both in the PHENIX and in the TOTEM experiments.

In our **theoretical femtoscopy related research**, related to proton-proton and heavy ion physics at RHIC and LHC,

- We have published in EPJ C our first results on a model-independent Levy series expansion, that revealed an important model-independent difference between the four-momentum-transfer dependent nuclear slope parameter $B(t)$ in proton-proton and in proton-antiproton elastic collisions at LHC. This result is a **clear-cut Odderon effect, indicating the discovery of a new quasi-particle at LHC**, a vector glueball - a quarkless bound state of odd, predominantly 3, number of gluons.

In our **experimental femtoscopy research in the CERN LHC experiment TOTEM**, during 2019 we have made significant contributions to the

- TOTEM publication of the differential cross-section of elastic proton-proton (pp) collisions at 13 TeV: an [EPJ C cover story in October 2019](#)
- measurement of the differential cross-section of elastic pp collisions at 2.76 TeV, and to the
- recalibration of the LHC optics with elastic pp scattering in the PPS project of CMS
- for his innovative, original and careful determination of the LHC optics from the PPS data, a key ingredient for all analyses based on PPS information in CMS and TOTEM, F. Nemes received the [2019 CMS Achievement Award](#)

In our **PHENIX related femtoscopy research**, we have made two important discoveries in 2018:

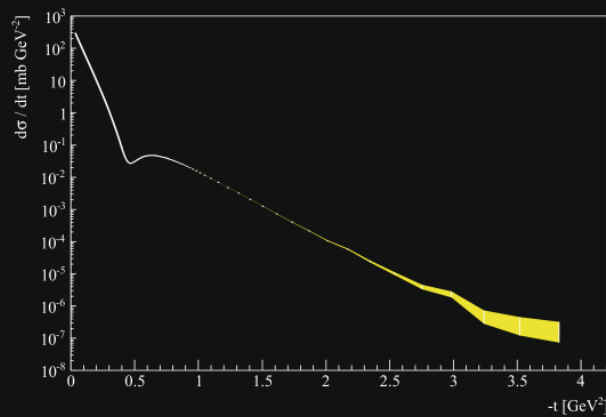
- In p+Au, d+Au and ³He+Au collisions at $\sqrt{s_{NN}} = 200$ GeV feature **droplets of a perfect fluid with three distinct geometries** on the femtometer scale, thus tiny droplets of strongly interacting quark gluon plasma can be engineered. This PHENIX result was published in online in December 2018 in **Nature Physics**, however we mention it again as this result became a Nature Physics cover story in **March 2019**: <https://www.nature.com/nphys/volumes/15/issues/3>

Grants:

- Principal Investigator NKFIH K 133 046 (PI: T. Csörgő, Wigner)
- Participation, NKTIH FK 123842 and FK 123959 grants (PI: M. Csanád, ELTE & A. László, Wigner)
- Participation in EFOP EFOP 3.6.1-16-2016-00001 grant (PI: Papp József, EKE)
- Participation in WG0839/2018 Circles of Knowledge Club – Wigner RCP sponsorship agreement

International cooperations:

- **PHENIX** Collaboration (**Brookhaven National Laboratory, USA**): Memorandum of Understanding between the **PHENIX** Experiment and KFKI representing the PHENIX-Hungary team (Hungarian Principal Investigator: M. Csanád (ELTE), participants in 2019: T. Csörgő, D. Kincses, T. Novák
- **TOTEM** Collaboration (CERN LHC, Svájc). Hungarian Principal Investigator: T. Csörgő, other participants in 2019: T. Csörgő, F. Nemes, T. Novák, I. Szanyi, J. Sziklai.
- **CERN**, Memorandum of Understanding for Collaboration in the Construction of the **TOTEM** detector and Memorandum of Understanding for the Maintenance and Operation of the TOTEM detector at LHC (Hungarian Principal Investigator T. Csörgő (Wigner RCP and EKE KRC). During 2019 this membership lead us to participation in the **CMS** experiment, particularly in the CMS Precision Proton Spectrometer project, too.
- **Lund University** (Lund, Sweden) – Wigner RCP, Memorandum of Understanding on bilateral collaboration (T. Csörgő, A. Ster, with L. Lönnblad , G. Gustafson and R. Pasechnik from Lund).
- **State University of New York at Stony Brook** (Stony Brook, NY, USA) – Wigner RCP, Memorandum of Understanding on bilateral international collaboration (PIs T. Csörgő, R. Lacey (SUNY SB)). Participants in this collaboration: T. Csörgő, D. Kincses.
- **Radboud University** (Nijmegen, The Netherlands) Bilateral international collaboration. Participants during 2019: T. Csörgő, T. Novák as well as W. Metzger (Nijmegen).
- **Central China Normal University, Wuhan, China**: Bilateral international collaboration. Participants during 2019: T. Csörgő, G. Kasza as well as Z.-F. Jiang (Wuhan).



Differential elastic cross-section $d\sigma/dt$ at $\sqrt{s} = 13$ TeV.
The statistical and $|t|$ -dependent correlated systematic
uncertainty envelope is shown as a yellow band.

From G. Antchev et al.:

Elastic differential cross-section measurement at $\sqrt{s} = 13$ TeV by TOTEM.



Figure 1: EPJ C October 2019 cover story: Differential cross-section of elastic proton-proton scattering as measured by the TOTEM Collaboration (G. Antchev, ... M. Csanád, T. Csörgő, F. Nemes, T. Novák, J. Sziklai et al) at CERN LHC. (Corresponding author: F. Nemes, corresponding TOTEM editor: T. Csörgő).

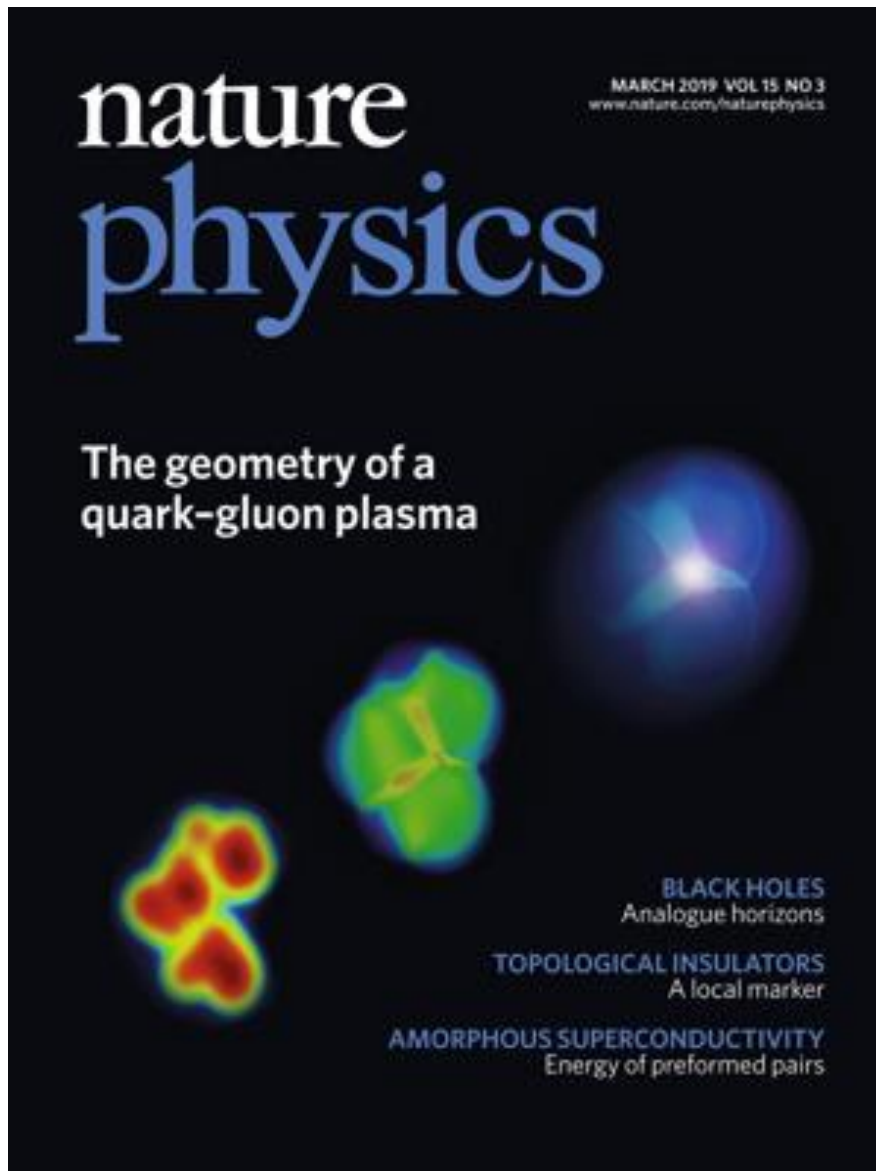


Figure 2: *Creation of quark–gluon plasma droplets with three distinct geometries*, **Nature Physics** cover story, **March 2019** (published online on December 10, 2018), **DOI:** [10.1038/s41567-018-0360-0](https://doi.org/10.1038/s41567-018-0360-0) by **PHENIX Collaboration:** Aidala C, Akiba Y, Csanád M, [Csörgő T](#), [T. Novák](#), [J. Sziklai](#) et al.