2023 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Search for exotic hadrons at BESIII

Helmholtz Centre and/or institute:

Helmholtz Institute Mainz (HIM) – GSI Helmholtzzentrum für Schwerionenforschung

Project leader:

Univ.-Prof. Dr. Achim Denig (section leader of research section SPECF of HIM)

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https://www.hi-mainz.de/research/research-sections/specf-spectroscopy-flavour/

Department: (at the Helmholtz centre or Institute)

Research Section SPECF of the Helmholtz Institute Mainz (HIM)

Programme Coordinator (Email, telephone and telefax)

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Description of the project (max. 1 page)**:**

Within the research project proposed here, we aim to search for new – so called exotic – types of hadronic matter with the exchange boson of the strong interaction, the gluon, acting as a constituent. Such gluonic hadrons, hybrid mesons containing a gluon in addition to a quark anti-quark pair and glueballs made entirely out of gluons, have been discussed as early as 1976. Modern calculations of Quantum Chromodynamics (QCD), the theory of the strong interaction, predict the existence of these exotic types of matter. While some candidate particles have been observed in experiment, there is no clear identification of a gluonic hadron yet. Finding them and studying their properties is of high importance for our understanding of the strong interaction and QCD as its underlying theory.

The BESIII experiment in Beijing enables unique searches for hybrid mesons and glueballs using complementary production mechanisms. Especially the experimental data collected at the J/psi resonance with 10 billion produced J/psi particles together with the corresponding world-leading psi(2S) data set offer a highly attractive environment to discover exotic hadrons in a gluon-rich laboratory. Existing results have shown a number of highly exciting findings, which are however not yet fully conclusive. Within this project, we intend to combine the above-mentioned physics analyses of charmonium resonances with

analyses carried out by the Mainz group in the area of photon-photon scattering. In this approach, the usual background from electron-positron annihilation is drastically reduced and, furthermore, hadronic resonances with selected quantum numbers – including exotic ones – can only be produced. As the photon-photon scattering reaction produces hadrons in an essentially gluon- and quark-free environment, the production of gluonic excitations should be supressed and therefore the combined investigation with charmonium resonance decays offers new and exciting insights into our understanding of exotic hadrons. The accuracy of photon-photon interactions at BESIII will greatly benefit from the upcoming new data set at 3.773, in which 20 fb^{-1} of integrated luminosity will be existing. It is also important to mention that the work carried out will also be beneficial for an improved understanding of the hadronic light-by-light (HLbL) contribution to the anomalous magnetic moment of the muon, $(g-2)_\mu$, which is a highly sensitive precision observable to look for Physics beyond the Standard Model of particle physics.

The research project will be carried out in cooperation with the hadron phenomenology and lattice QCD groups at the Johannes Gutenberg University and the Helmholtz Insitute Mainz as well as theoreticians at GSI. Furthermore, the work will have connections to the DFG-funded Research Unit FOR 5327 “Photon-Photon Interactions in the Standard Model and Beyond” and with the PANDA collaboration, where the search for exotic hadrons will be possible in yet another environment (proton-antiproton annihilation). In conclusion, with the proposed work and with the excellent opportunities existing at a later stage at PANDA@FAIR, we aim to finally answering the question about the existence of gluonic hadrons in order to gain a unique new insight into the strong interaction.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

The project leader is already cooperating with Chinese research institutions and Universities within the international BESIII and PANDA collaborations. While BESIII, being located in Beijing/China, has obviously a large number of collaborating institutions from China, the situation is different in the case of PANDA, where currently only few Chinse institutions are cooperating (e.g. IHEP/Beijing and USTC/Hefei).

The HGF-OCPC programme offers an excellent opportunity to strengthen the links between China and Germany and to broaden this link also towards the PANDA collaboration and FAIR. We envisage a new quality of research since the focus of the German and Chinese partners should ideally complement each other. Furthermore, we also see excellent opportunities to establish cooperations with the world-leading theory groups in the field of hadronic physics at Mainz and the Chinese partners, especially in the area of hadron spectroscopy.

Required qualification of the postdoc:

- PhD in Nuclear of Hadron Physics
- Experience with Data Analysis, Monte-Carlo Simulation
- Additional skills in Statistical Methods, Writing of Scientific Publications
- Language requirement: English language (speaking and writing)