GPDPortal

A virtual-access portal for the study and extraction of generalized parton distributions through exclusive processes

V. Bertone[a,1], B. Blossier[b], G. Duplančić[c], K. Kumerički[d], C. Lorcé[e], C. Merzrag[a], B. Pasquini[f], K. Passek-K.[c], P. Sznajder[g], L. Szymanowski[g], J. Wagner[g], S. Wallon[b]

[a] IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France
[b] Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405, Orsay, France
[c] Division of Theoretical Physics, Rudjer Bošković Institute, HR-10000 Zagreb, Croatia
[d] Department of Physics, Faculty of Science, University of Zagreb, HR-10000 Zagreb, Croatia
[e] CPHT, CNRS, École Polytechnique, Institut Polytechnique de Paris, 91120 Palaiseau, France
[f] Department of Physics, University of Pavia and INFN - Sezione di Pavia, Via Bassi 6, I-27100 Pavia, Italy
[g] National Centre for Nuclear Research, NCBJ, 02-093 Warsaw, Poland

1 Scientific context and objectives

Hadron structure is an extremely wide and multifaceted research field under constant development. From a phenomenological viewpoint, this field can be attacked from two separate fronts: *inclusive* and *exclusive* processes. The inclusive side, thanks to past and present high-energy facilities at CERN, FermiLab, DESY, etc. has witnessed an impressive progress, leading to very precise parton distribution functions (PDFs), being followed at a fast pace by transverse-momentum-dependent distributions (TMDs). On the exclusive front, progress, while still considerable, has been slower. One of the concurring factors is that exclusive processes are typically more sensitive to subleading contributions, which complicates their description within the framework of perturbative QCD. Indeed, an accurate partonic description of exclusive processes is typically affected by large perturbative and power corrections (higher twists), which are hard to compute. Another, no less important factor that has limited the development of exclusive physics is the lack of adequate numerical tools and resources. As a demonstration, as of today, a fully-fledged phenomenological determination from a global set of data of generalised parton distributions (GPDs), directly involved in exclusive processes, is still missing. Acknowledging this gap, GPDs are now at the core of experimental programs at various international facilities, including Jefferson Lab, COMPASS/AMBER at CERN, and the future Electron Ion Collider (EIC).

Thanks to the resources provided by the STRONG2020 programme, specifically through the `3DPartons` virtual-access package, the gap has begun to be filled. Indeed, a number of solid and accurate numerical tools aimed at the study and determination of GPDs were made publicly available, which imparted a significant acceleration to the field. In view of this, we advocate for more resources to be allocated to grant continuity to the achievements of `3DPartons` and to widen its scope. More specifically, following the groove of `3DPartons`, the purpose of this Virtual-Infrastructure (VI) initiative, which we dubbed **GPDPortal**, is to *aggregate in a coherent fashion existing numerical tools;* but ***also***, to *broaden the range of applications by leveraging European-wide expertise on GPDs and exclusive processes to develop and maintain new tools aimed at solving relevant open problems*.

1.1 Implementation

GPDPortal is conceived to provide access, maintenance, and support to existing and forthcoming numerical tools related to the study of GPDs and exclusive processes through a centralised web portal. We plan to continue the development and integration of existing tools, such as the `Gepard` and `PARTONS` platforms, the `EPIC` Monte Carlo generator, and the associated database system (see arXiv:2503.18152). The goal is to ensure seamless interoperability between components through numerical computation and event generation. This infrastructure will finally enable precision phenomenology for a broad class of processes aimed at the analysis of experimental and lattice data and the extraction of information on GPDs and gravitational form factors.

A large number of GPD parameterisations will be made available within GPDPortal. This includes models based on more traditional functional forms as well as on neural networks. Moreover, we will

[1] Coordinator.

give access to parameterisations in conformal space, double-distribution space and direct space. When relevant, we will also incorporate advanced models for meson distribution amplitudes (DAs) and transition distribution amplitudes (TDAs).

To address the increasing precision of the data from current and forthcoming experiments (JLab, LHC, EIC), we will extend the theoretical framework to include **next-to-leading order** (NLO) and **higher-twist** (HT) **corrections**. We will address the question of GPD **evolution** by making available fast and reliable codes that perform evolution up to NLO. This will also entail the computation and the implementation of the NLO matching coefficients at heavy-quark mass thresholds. Particularly relevant is the case of deeply-virtual meson production (DVMP), for both vector and pseudoscalar mesons, as well as photon–meson and meson–pair photoproduction. We will extend and optimise existing codes and integrate them into the platform. Particular emphasis will be put on developing tools capable of performing **fast and reliable numerical evaluations**.

Another important element of the GPDPortal development programme is the inclusion of hard exclusive **2 → 3 processes**, such as $\gamma^{(*)}N \to \gamma M'N'$ and $\gamma^{(*)}N \to MM'N'$ for which we plan to achieve **full automation** for the computation up to NLO of the relevant hard cross sections, for any meson M for which collinear factorisation is not violated. These processes provide a new set of observables, complementary to deeply-virtual Compton scattering (DVCS) and DVMP, which will give us direct access to both **chiral-even and chiral-odd GPDs**.

A yet new family of exclusive processes involves backward-angle reactions, which are sensitive to **TDAs**. These processes, such as backward meson electroproduction or nucleon-antinucleon annihilation into a photon and a meson, provide complementary access to hadron structure. We plan to initiate the development of a **dedicated set of numerical tools** capable of describing these reactions.

GPDs are a unique tool to study **mechanical properties of hadrons,** as they provide direct access to the **energy-momentum-tensor** form factors (FFs). GPDPortal will leverage this connection to enforce mechanical constraints on GPD extractions, such as those related to the positivity of energy. We also envisage a dispersive analysis of exclusive photo(electro)production of heavy-mesons to access the **gravitational FFs** of the nucleon, and of the ***D*-term** in t-channel DVCS off a pion.

The ongoing progress in **lattice QCD** opens up the opportunity to incorporate lattice results into global analyses of exclusive processes. Quantities computed on the lattice can provide valuable input to hadron-structure studies. To enable this, we plan to extend the 3DPortal framework to handle lattice observables alongside experimental data in a format suitable for comparison and fitting procedures.

2. Connection to Transnational Access infrastructures and Virtual Access projects

GPDPortal is tightly connected with three VA project proposals:

- VI TMDPortal (A. Bacchetta *et al.*),
- VI NuSKAT (P. Chatagnon *et al.*),
- VI NLOAccess (J.P. Lansberg *et al.*).

3. Estimated budget request

We request 15 postdoc-years to be shared between the institutions involved for hiring personnel devoted to development, maintenance, and support of the GPDPortal infrastructure, for an estimated cost of 900 k€. Moreover, we request 60 k€ for the purchase of servers and cluster nodes needed to run the portal. Finally, we request 40 k€ to devote to the organisation of schools and workshops, and the training of users. The total cost amounts to 1 M€.

4. Participating and partner institutions

The following institutions will contribute to this project as developers and maintainers of GPDPortal: IRFU/CEA Paris-Saclay, University of Zagreb, École Polytechnique, University of Pavia, Rudjer Bošković Institute, NCBJ Warsaw, IJCLab Orsay.