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Book of Abstracts

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Exclusive vector meson production with Sar*t*re using machine learning in eA collision.

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We use Machine Learning with the event-generator (Sar*t*re) for
the for exclusive diffraction processes in electron-nucleus scattering. The second moment of the amplitude includes averaging of hundreds of initial nucleon configurations of the heavy nucleus, a procedure which is extremely CPU intense. We show that we can make the production of the cross-sections used for event generation at least 90% more efficient using machine learning. Sartre is using lookup tables for the first and second amplitude of the interaction. With our new technique, the production time of these lookup tables is reduced from several months to a few days. This will enable us to generate exclusive diffraction events for all heavy nuclear species, with any exclusive final state.

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Search for effective Lorentz and CPT violation using ZEUS data

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Lorentz and CPT symmetry in the quark sector of the Standard Model are studied in the context of an effective field theory using ZEUS e±p data. Symmetry-violating effects can lead to time-dependent oscillations of otherwise time-independent observables, including scattering cross sections. An analysis using five years of inclusive neutral-current deep inelastic scattering events corresponding to an integrated HERA luminosity of 372 pb-1 at sqrt(s) = 318 GeV has been performed. No evidence for oscillations in sidereal time has been observed within statistical and systematic uncertainties. Constraints, most for the first time, are placed on 42 coefficients parameterising dominant CPT-even dimension-four and CPT-odd dimension-five spin-independent modifications to the propagation and interaction of light quarks.

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Measurement and QCD analysis of inclusive jet production in deep inelastic scattering at HERA

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A new measurement of inclusive jet cross sections in neutral current deep inelastic scattering using the ZEUS detector at the HERA collider is presented. The data were taken at HERA in the years 2004

to 2007 at a centre-of-mass energy of 318 GeV and correspond to an integrated luminosity of 347 pb-1. Massless jets, reconstructed using the kT-algorithm in the Breit reference frame, have been measured as a function of the squared momentum transfer, Q2, and the transverse momentum of the jets in the Breit frame, p_{T,Breit}. The measured jet cross sections are compared to previous measurements as well as perturbative QCD predictions. The measurement has been used in a next-to-next-to-leading-order QCD analysis to perform a simultaneous determination of parton distribution functions of the proton and the strong coupling constant αs(MZˆ2). A significantly improved accuracy is observed compared to similar measurements of the strong coupling constant.

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Measurement of the azimuthal decorrelation angle between the leading jet and the scattered lepton in deep inelastic scattering at HERA

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The azimuthal decorrelation angle Δφ between the leading jet and scattered lepton in deep inelastic scattering has been measured with the ZEUS detector at HERA.The experimental data set was taken in the HERA II data-taking period and corresponds to an integrated luminosity of 326 pb-1. The measurement was performed within a range of the exchanged photon virtuality Q2 from 10 to 350 GeV2, the lepton energy Ee > 10 GeV, and the lepton angle 140 < θe < 180. The jets were measured in the transverse-momentum and pseudorapidity ranges 2.5 GeV < p_{T,jet} < 30 GeV and −1.5 < eta_{jet} < 1.8. The differential cross section was normalized to the inclusive cross section and are presented here as a function of Δφ in various ranges of p_{T,jet}, Q2 and the jet multiplicity. The measurements obtained in this study show good agreement with predictions from perturbative calculations up to next-to-next-to-leading order.

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The LHCspin project

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The goal of LHCspin is to develop, in the next few years, innovative solutions and cutting-edge technologies to access spin physics in high-energy polarized fixed-target collisions, by exploring a unique kinematic regime given by the LHC beam and by exploiting new probes.
This ambitious task poses its basis on the recent installation of SMOG2, the unpolarized gas target in front of the LHCb spectrometer. Specifically, the unpolarized target, already itself a unique project, will allow to carefully study the dynamics of the beam-target system, and clarify the potentiality of the entire system, as the basis for an innovative physics program at the LHC.
The forward geometry of the LHCb spectrometer (2<⊠<5) is perfectly suited for the reconstruction of particles produced in fixed-target collisions. This configuration, with center-of-mass energies ranging from 115 GeV in pp interactions to 72 GeV in collisions with nuclear beams, allows to cover a wide backward rapidity region, including the poorly explored high x-Bjorken and high x-Feynman regimes. With the instrumentation of the proposed target system, LHCb will become the first experiment delivering simultaneously unpolarized beam-beam collisions at √s=14 TeV and both polarized

and unpolarized beam-target collisions.
The status of the project is presented along with a selection of physics opportunities.

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Geometric scaling in leading neutron events at HERA

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This analysis provides new fits of the GBW model and the impact parameter-dependent saturation model (bSat or IP-Sat) to the leading neutron structure function HERA data in one-pion exchange approximation. Both parametrizations of the dipole cross section provide good descriptions of the considered data. It is shown here for the first time that the experimental leading neutron production HERA data exhibits geometric scaling, which in this context means that the total $\gamma^*\pi^*$ cross section is a function of only one dimensionless variable $\tau = Q^2/Q_s^2(x)$. The geometric scaling region extends over a broad range of Q^2 and can be attributed to the presence of a saturation boundary which manifests at $Q^2 \geq Q_s^2$. The scaling behaviour in leading neutron events is profoundly similar to what has been observed for the inclusive DIS events.

1. A. Kumar, Geometric scaling in leading neutron events at HERA, Phys. Rev. D 107, 034005 (2023).
2. A. Kumar and T. Toll, Investigating saturation effects and the virtual pion in leading neutron events at HERA with the dipole model, Phys. Rev. D 105, 114045 (2022).

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Hadron production and forward proton measurements with ATLAS

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Measurements of hadron production provide important insight about the quark and gluon fragmentation that are relevant for the simulation of kinematic distributions of high-energy collisions. The measurement of charged particle distributions using LHC proton-proton data collected at 13.6 TeV of centre-of-mass energy will be presented. The differences in the production with and without accompanying forward protons will be highlighted. In addition, the production of charged particle production in photo-nuclear interactions using lead-lead collisions at 5 TeV will be discussed and contrasted with photo-nuclear proton-lead events at the same collision energy. The spectra of correlated hadron chains are explored in p-p, p-lead, and lead-lead collisions and compared to the predictions based on the quantized fragmentation of a three-dimensional QCD helix string. Finally, the talk will describe a recent result of the search for Axion Light Particles utilising two photons and forward protons in the event.

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Jet, heavy flavour and photon production at ATLAS

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The production of jets and prompt isolated photons at hadron colliders provides stringent tests of perturbative QCD. The most recent measurements in this area by the ATLAS experiment, using proton-proton collision data at $\sqrt{s}$ =13 TeV, are presented. Prompt inclusive photon production is measured for two distinct photon isolation cones, R=0.2 and 0.4, as well as for their ratio. The measurement is sensitive to gluon parton density distribution. Various measurements of event shapes in multijet events are presented, as well. The talk will discuss measurements of new event-shape jet observables defined in terms of reference geometries with cylindrical and circular symmetries using the energy mover???s distance, as well as variables probing the properties of the multijet energy flow. The latter are also used to determine the strong coupling constant. The measurements are compared to state-of-the-art theory predictions from a range of parton shower programs and fixed order calculations. Furthermore, measurements of jets in association with an electroweak gauge boson are highlighted. The differential measurement of W boson production in association with charm D+ and D*+ vector mesons will be discussed and compared to QCD calculations including NNLO parton distribution functions and constraints on parton distribution functions. Recent results of Z+jets production using new machine-learning techniques to extract multi-differential cross sections will be presented. The measurements are compared to state-of-the-art theory predictions.

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Precision measurements of W production at ATLAS

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The indirect determination of the W-boson mass from global electroweak fits outperforms the precision of its experimentally measured value. An improved experimental measurement is therefore one of the goals of the LHC physics program. The talk will present a re-analysis of the mass of the W boson at a centre-of-mass energy of 7 TeV using a profile likelihood fit, which improves the precision of the mass determination by 15% by fully exploiting the information present in data. The talk will also present the transverse momentum of the W and Z boson measured from the hadronic recoil at 5 and 13 TeV using dedicated LHC runs with reduced instantaneous luminosity. The measurement provides a fundamental input to reduce the physics-modeling uncertainties in future W-boson mass determinations.

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Precision measurements of Z production at ATLAS

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Precision measurements of the production cross-sections of Z bosons at LHC provide important tests of perturbative QCD and constrain the parton distribution functions for quarks within the proton. This talk will present an extraordinarily precise double-differential measurement of the Z boson in the full phase space of the decay leptons at a centre-of-mass energy of 8 TeV. The recoil of the Z-boson is sensitive to quark and gluon emissions and is used to determine the strong coupling constant in a novel approach using the Sudakov region. If available, a measurement of Drell-Yan production at high invariant mass using 13 TeV data will also be presented. The results are compared to state-of-the-art predictions in perturbative QCD, supplemented by resummation of logarithmically-enhanced contributions in the small transverse-momentum region of the lepton pairs.

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On the exact solution for the Schrödinger equation

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For almost a century, the general solution for the Schrödinger equation was assumed to be generated by a time-ordered exponential known as the Dyson series. We discuss under which conditions the unitarity of this solution is broken, and additional discrete dynamics emerges. Then, we provide an alternative construction that is manifestly unitary, regardless of the Hamiltonian and the setup. The new construction involves an additional Hermitian operator with a singular time dependency and evolves in a non-gradual way. Its dynamics exhibit the behavior of a collective object governed by Liouville's equation, performing transitions at a measure 0 set of times. Our considerations show that Schrödinger's and Liouville's equations are, in fact, two sides of the same coin, and together they become the unified description of quantum systems in the fractalic regime.

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Next-to-leading order photon+jet production

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Using the CGC effective theory together with the hybrid factorisation, we study forward photon+jet production in proton-nucleus collisions beyond leading order. We first compute the "real" next-to-leading order (NLO) corrections, i.e. the radiative corrections associated with a three-parton final state, out of which only two are being measured. Then we move to the "virtual" NLO corrections to dijet production, in which a gluon loop is included as a part of the amplitude, before or after the measurement. Each of these loop diagrams diverges, and we explain our treatment in order to obtain finite expression for the cross section.
We explicitly work out the interesting limits where the unmeasured gluon is either a soft, or the product of a collinear splitting. We find the expected results in both limits: the B-JIMWLK evolution of the leading-order dijet cross-section in the first case (soft gluon) and, respectively, the DGLAP evolution of the initial and final states in the second case (collinear splitting).

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QCD corrections to quarkonium production

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I will review the impact of QCD corrections to quarkonium production in inclusive and exclusive reactions. First, I will explain how they significantly alter the cross section at mid and large p_T in inclusive photo- and hadro-production. Second, I will discuss the perturbative instability arising at high energies in p_T-integrated fixed-order computations and discuss how they can be dealt with either via a specific factorisation-scale choice or by resummation of high-energy logarithms via high-energy factorisation. Third, I will focus on exclusive photoproduction plagued by the same high-energy perturbative instabilities and exclusive production in photon fusion.

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Computing one-loop corrections to quarkonium production impact-factors with Lipatov's EFT

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The formalism of gauge-invariant EFT for Multi-Regge processes in QCD is used to compute impact-factors relevant for processes of production of heavy quarkonia within Non-Relativistic QCD Factorisation formalism and High-Energy Factorisation at one-loop accuracy. The examples of $\gamma + R \to c\bar{c}\left[{}^1S_0^{[8]}\right]$ and $g + R \to c\bar{c}\left[{}^1S_0^{[1]}\right]$ impact factors will be considered, with R being the Reggeized gluon and the final-state $c\bar{c}$ pair is projected on a specified state ${}^{2S+1}L_J^{[1,8]}$. In the process of computation, the one-loop integrals with rapidity divergences and massive internal lines have been encountered and procedure for their computation has been developed. The results for the impact-factor in the EFT has been cross-checked against the Regge limit of an exact one-loop QCD amplitude $\gamma + g \to c\bar{c}\left[{}^1S_0^{[8]}\right] + g$, which is another highly nontrivial check of the EFT formalism. The results will be applied to computation of p_T-integrated cross sections of inclusive J/ψ photoproduction and η_c hadroproduction in the matching approach of Refs.[1,2].

[1] https://arxiv.org/abs/2306.02425

[2] https://arxiv.org/abs/2112.06789 [JHEP 05 (2022) 083]

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Imaging the odderon from exclusive eta_c production at the EIC

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In this contribution I would like to report on our recent findings [1] regarding the exclusive eta_c production in e+p and e+A collisions that is sensitive to the Odderon. We are working within the framework of Color Glass Condensate applicable at the high energies that would be reached at future electron ion colliders. The Odderon distribution at small-x is found by explicitly solving the Balitsky-Kovchegov equation with running coupling corrections. For the initial condition for proton targets we are using the very recent quark light-cone wave function based model from [2], while for the nuclei we are using the semi-classical initial condition from [3]. Our findings are:

1. The Odderon component of the cross section on a proton target at low momentum transfers is found to be dominated by the Primakoff component. Thanks to the Landshoff mechanism [4] the Odderon cross section shows an almost flat behavior in the high-t region reaching above the Primakoff component.
2. Considering instead exclusive etac production off a neutron target the Odderon distribution can be probed even at small-t thanks to a significant suppression of the Primakoff component.
3. Finally for nuclear targets, the multiple scattering effect leads to a shift in the diffractive pattern of the Odderon cross section with respect to the Primakoff process that could be used as a signal to detect the Odderon.

[1] SB, Horvatic, Kaushik, Vivoda, 2306.10626
[2] Dumitru, Mantysaari, Paatelainen, Phys. Rev. D 107 (2023) 1, L011501

[3] Jeon, Venugopalan, Phys. Rev. D 71 (2005) 125003
[4] Donnachie, Landshoff, Z. Phys. C 2 (1979) 55, Z.Phys.C 2 (1979) 372 (erratum)

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Back-to-back dijets at the EIC: small x and Sudakov resummation

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We present our recent calculation of the dijet electroproduction cross section at the NLO accuracy within the Color Glass Condensate effective field theory. We focus on kinematical regime where the two jets are forward w.r.t. projectile's longitudinal direction and are almost back-to-back in transverse plain. We discuss the interplay between small-x and Sudakov resummation and show numerical results for the EIC kinematics.

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Factorisation of 1-loop amplitudes in NMRK limits

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There has been much recent progress towards extending the BFKL equation to next-to-next-to-leading logarithmic (NNLL) accuracy. In this talk I will briefly review the status of this programme of research. I will then discuss our recent progress in extracting some of the missing ingredients of the NNLL kernel, including the one-loop central-emission vertex (CEV) for two gluons which are not strongly ordered in rapidity. I will emphasise the non-trivial colour structure that remains after taking next-to-multi-Regge (NMRK) limits of one-loop amplitudes in QCD.

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Lévy α-stable model for the non-exponential low-|t| proton-proton differential cross section

Authors: Tamas Csorgo[1]; Istvan Szanyi[2]

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It is known that the Real Extended Bialas-Bzdak (ReBB) model describes the proton-proton (pp) and proton-antiproton ($p\bar{p}$) differential cross section data in a statistically not excludible way, i.e., with a confidence level greater than 0.1% in the center of mass energy range 546 GeV $\leq \sqrt{s} \leq 8$ TeV and in the squared four-momentum transfer range 0.37 GeV$^2 \leq -t \leq 1.2$ GeV^2. Considering, instead of Gaussian, a more general Lévy α-stable shape for the parton distributions of the constituent quarks and diquarks inside the proton and for the relative separation between them, a generalized description of data is obtained, where the ReBB model corresponds to the $\alpha = 2$ special case. Extending the model to $\alpha < 2$, we conjecture that the validity of the model can be extended to a wider kinematic range, in particular to lower values of the four-momentum transfer $-t$. We present the formal Lévy α-stable generalization of the Bialas-Bzdak model and show that a simplified version of this model can be successfully fitted, indeed with $\alpha < 2$, to the non-exponential, low $-t$ differential cross-section data of elastic proton-proton scattering at $\sqrt{s} = 8$ TeV.

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Transverse analyzing power measurement in the high energy forward $p^{\uparrow}p$ and $p^{\uparrow}A$ scattering at RHIC hydrogen jet target polarimeter

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The Polarized Hydrogen Gas Jet Target Polarimeter (HJET) at the Relativistic Heavy-Ion Collider (RHIC) is utilized to accurately measure the vertical polarization of proton beams with low systematic uncertainties of approximately $\sigma_P^{\text{syst}}/P \leq 0.5\%$. These measurements are conducted in the CNI region, $0.0013 < |t| < 0.017$ GeV^2. By measuring the elastic single $A_{\text{N}}(t)$ and double $A_{\text{NN}}(t)$ spin analyzing powers for 100 and 255 GeV proton beams, the contributions from hadronic spin-flip amplitudes were isolated. A Regge fit was performed, revealing a non-zero Pomeron spin-flip component. Preliminary results for inelastic $p^{\uparrow}p$ and elastic $p^{\uparrow}A$ (for d, O, Al, Ru, Zr, and Au nuclei) analyzing powers were also obtained. However, the completion of these studies requires the development of a theoretical parametrization for the corresponding analyzing powers. The successful implementation of HJET at RHIC has prompted its potential use for proton beam polarimetry with a desired accuracy of 1\% at the upcoming Electron-Ion Collider (EIC). The feasibility of using HJET for ^{3}He (h) beam polarimetry at EIC will also be discussed. To accurately measure the helion beam polarization using HJET, knowledge of the hadronic spin-flip amplitudes for the $p^{\uparrow}h$ and $h^{\uparrow}p$ is essential. These amplitudes can be derived with sufficient precision from the proton-proton hadronic spin-flip amplitude determined at HJET. Another potential concern for ^{3}He polarization measurement is the possibility of helion breakup in hp scattering. An estimate of the breakup effect indicates that while it can introduce corrections of up to 4\% to the spin-flip interference terms, these effects cancel out and have negligible impact on the calculating the ^{3}He beam polarization (which depends on the effective $A_{\text{N}}^{ph}(t)/A_{\text{N}}^{hp}(t)$ analyzing power ratio).

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Physics with proton/neutron tagging in pp, pO collisions at the LHC.

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The talk will cover several research opportunities with tagged forward protons/neutrons using the proton-proton and proton-Oxygen collisions at the Large Hadron Collider.

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Welcome

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QCD corrections to quarkonium production

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Discussion: low x, saturation, final states

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QCD corrections to quarkonium production

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Computing one-loop corrections to quarkonium production impact-factors with Lipatov's EFT

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Measurement of the azimuthal decorrelation angle between the leading jet and the scattered lepton in deep inelastic scattering at HERA

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Geometric scaling in leading neutron events at HERA

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Factorisation of 1-loop amplitudes in NMRK limits

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Diffraction and photon exchanges / **135**

Search for effective lorentz violation and CPT violation in ZEUS data

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On color reconnection effects in J/psi hadroproduction

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New results constraining transversity in high-energy polarized p+p collisions

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Associated production of vector bosons and heavy flavours in CMS

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Discussion: final states, quarkonium

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Dilepton and diphoton production and BSM searches with UPC photon fusion processes in Pb+Pb collisions with the ATLAS detector

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Transverse analyzing power measurement in the high energy forward pp and pA scattering at RHIC hydrogen jet target polarimeter

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The LHCspin project

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Recent results on direct determination of the Collins-Soper kernel and how to measure it at the LHC?

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On the exact solution for the Schrödinger equation

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Discussion: final states

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Workshop conclusion

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