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Small-x Quark and Gluon Helicity and OAM Contributions to the Proton Spin Puzzle

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One of the fundamental questions in our understanding of the proton structure is the proton spin puzzle. Theoretically, adding all the helicities and orbital angular momenta (OAM) of the quarks and gluons in the proton should give us 1/2, the spin of the proton. At the same time, adding the experimentally measured spin carried by the quarks and gluons in the proton comes up short, presently giving us a number in the 0.3-0.4 range. This decades-old discrepancy is known as the "proton spin puzzle". In this talk we will discuss the possibility that the missing spin of the proton can be carried by quarks and gluons carrying a small fraction x of the proton momentum. This contribution is mostly beyond the reach of current experiments and is very hard to calculate numerically on the lattice. It appears that an improved theoretical understanding of quark and gluon helicity and OAM distributions at small x is needed to assess the amount of proton spin coming from this region. In this talk I will describe the work of my group to construct such a theory: I will derive the novel small-x evolution equations for helicity and solve them to find the small-x asymptotics of the quark and gluon helicity and OAM distributions. I will show how these equations can be used to obtain a first-ever fit of the world polarized DIS and SIDIS data for x<0.1 based solely on small-x helicity evolution. The resulting amount of the proton spin coming from the small-x region appears to be significant, opening a tantalizing possibility that the proton spin puzzle can be resolved by including this small-x contribution. We will conclude by describing how the upcoming Electron-Ion Collider (EIC) can further test our theoretical formalism and its predictions.

Presenter(s) : KOVCHEGOV, Yuri (Department of Physics, The Ohio State University)