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Bonner Prize: The Elastic Form Factors of the Nucleon

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A series of experiments initiated in 1998 at the then new Continuous Electron Beam Accelerator, or CEBAF in Newport News Virginia, resulted in unexpected results, changing significantly our understanding of the structure of the proton. These experiments used a relatively new technique to obtain the ratio of the two form factors of the proton, namely polarization. An intense beam of highly polarized electrons with energy up to 6 GeV was made to interact elastically with un-polarized protons in a hydrogen target. The polarization of the recoiling protons, with energies up to 5 GeV, was measured from a second interaction in a polarimeter consisting of blocs of graphite or CH2 and tracking wire chambers. The scattered electrons were detected in an electromagnetic lead-glass calorimeter, to select elastically scattered events. After a short introduction describing the path which brought me from the University of Geneva to the College of William and Mary in 1966, I will introduce the subject of elastic electron scattering, describe some of the apparatus required for such experiments, and show the results which were unexpected at the time. These results demonstrated unequivocally that the two form factors required to describe elastic ep scattering, electric G_E and magnetic G_M in the Born approximation, had a drastically different dependence upon the four-momentum squared $q^2 = q^2 - \omega^2$ with q the momentum, and ω the energy transferred in the reaction. The finding, in flagrant disagreement with the data available at the time, which had been obtained dominantly from cross section measurements of the type first used by Nobel Prize R. Hofstadter 60 years ago, have led to a reexamination of the information provided by form factors on the structure of the nucleon, in particular its quark-gluon content. The conclusion will then be a brief outline of several theoretical considerations to put the results in a proper perspective.