of the extracted parameters are again consistent with naïve expectations. For the magnetic moment of the proton, converting to units of nuclear magnetons using Eq. (25) yields

$$\mu_p^{\text{conn}}(m_\pi = 390\,\texttt{MeV}) = 2.63(13)(1)(4)\,[\mu_N].$$

We have appended a superscript to reflect that our computation includes only connected contributions; we have also added in the Dirac contribution, assuming $Q = 1$. The three uncertainties quoted are as before: (i) statistics and fitting, (ii) the systematic due to the fit window, and (iii) conversion to physical units. For (i), we take the central value and uncertainty from fit II. For the proton electric polarizability, converting the results of fit II to physical units using Eq. (26) yields

$$\alpha_E^{p\,\text{conn}}(m_\pi = 390\,\texttt{MeV}) = 2.4(1.9)(3)(2) \times 10^{-4}\texttt{fm}^3,$$

where the last uncertainty arises from scale setting.

Finally let us compare results for the neutron and proton. Within the uncertainty, the connected part of the isoscalar anomalous magnetic moment is consistent with zero. To compare with experiment, we require additional contributions from disconnected diagrams that we have not determined. The isovector combination of moments, however, does not have disconnected contributions due to strong isospin symmetry. For the nucleon isovector magnetic moment, we find

$$\mu_V(m_\pi = 390\,\texttt{MeV}) = 4.3(2)(1)(1)\,[\mu_N].$$

While this value is smaller than the physical moment, chiral corrections drive the magnetic moment downward at masses above the physical value [35, 36]. Studies at additional pion masses are necessary to extrapolate to the physical point. The value we obtain, moreover, is comparable to values extracted from the current insertion method at similar values of the pion mass, see [37].

For the electric polarizabilities, our results show both isovector and isoscalar components, however, the latter is the dominant one. This is also seen experimentally and from chiral perturbation theory. The smaller isovector component,

$$\alpha_E^V(m_\pi = 390\,\texttt{MeV}) = -0.9(2.5)(3)(4) \times 10^{-4}\texttt{fm}^3,$$

receives smaller chiral corrections, and is less sensitive to the electric charges of the sea (but not independent). While values for the electric polarizabilities of the neutron and proton are smaller than experiment, chiral perturbation theory suggests large corrections as one nears the chiral limit [38–41]. Additionally including contributions from sea quark electric charges will drive both polarizabilities upwards, as can be seen from partially quenched chiral perturbation theory [12]. It will be interesting to carry out simulations at additional quark masses and with electrically charged sea quarks to observe this behavior.

V. CONCLUSION

Above, we investigate the relativistic propagation of spin-half particles in classical electric fields. The presence of magnetic moments affects the behavior of two-point correlation functions, and we use this observation to devise a method to determine magnetic moments