

**Edwards, James P.**

**Contact interactions between particle worldlines.** (English) Zbl 1388.81973  
J. High Energy Phys. 2016, No. 1, Paper No. 33, 45 p. (2016).

Summary: We construct contact interactions for bosonic and fermionic point particles. We first relate the resulting theories to classical electrostatics by taking functional averages over worldlines whose endpoints are fixed to charged particles. Counting those paths which pass through a space-time point  $x^\mu$  gives the static electric field at that point, provided we take the limit where the length measured along the worldlines is large. We also investigate corrections to the classical field that arise beyond leading order in this limit before constructing a theory of point particles that interact when their worldlines intersect. We quantise this theory and show that the partition function contains propagator couplings between the endpoints of the particles before discussing how this is related to the worldline formalism of quantum field theory and general action at a distance theories.

**MSC:**

[81V35](#) Nuclear physics  
[78A35](#) Motion of charged particles

Cited in 4 Documents

**Keywords:**

[field theories in lower dimensions](#); [effective field theories](#); [confinement](#)

**Full Text:** [DOI](#) [arXiv](#)

**References:**

- [1] Edwards, JP; Mansfield, P., Delta-function interactions for the bosonic and spinning strings and the generation of abelian gauge theory, JHEP, 01, 127, (2015)
- [2] Edwards, JP; Mansfield, P., QED as the tensionless limit of the spinning string with contact interaction, Phys. Lett., B 746, 335, (2015) · [Zbl 1343.81217](#)
- [3] Mansfield, P., Faraday's lines of force as strings: from gauss' law to the arrow of time, JHEP, 10, 149, (2012) · [Zbl 1397.83165](#)
- [4] Strassler, MJ, Field theory without Feynman diagrams: one loop effective actions, Nucl. Phys., B 385, 145, (1992)
- [5] M.J. Strassler, \textit{Field theory without Feynman diagrams: A demonstration using actions induced by heavy particles}, SLAC-PUB-5978 (1992).
- [6] Bastianelli, F.; Corradini, O.; Pisani, PAG; Schubert, C., Scalar heat kernel with boundary in the worldline formalism, JHEP, 10, 095, (2008) · [Zbl 1245.81109](#)
- [7] Schubert, C., Perturbative quantum field theory in the string inspired formalism, Phys. Rept., 355, 73, (2001) · [Zbl 0988.81108](#)
- [8] Auer, T.; Schmidt, MG; Zahlten, C., Resummed effective action in the worldline formalism, Nucl. Phys., B 677, 430, (2004) · [Zbl 1097.81666](#)
- [9] Ilderton, A., Localisation in worldline pair production and lightfront zero-modes, JHEP, 09, 166, (2014) · [Zbl 1333.81282](#)
- [10] Mansfield, P., The fermion content of the standard model from a simple world-line theory, Phys. Lett., B 743, 353, (2015) · [Zbl 1343.81230](#)
- [11] Edwards, JP, Unified theory in the worldline approach, Phys. Lett., B 750, 312, (2015) · [Zbl 1364.81254](#)
- [12] Dietrich, DD, The fifth dimension in the worldline formalism, holography and the Wilson flow, Phys. Rev., D 89, 106009, (2014)
- [13] Wheeler, JA; Feynman, RP, Classical electrodynamics in terms of direct interparticle action, Rev. Mod. Phys., 21, 425, (1949) · [Zbl 0034.27801](#)
- [14] Kerner, EH, Hamiltonian formulation of action-at-a-distance in electrodynamics, J. Math. Phys., 3, 35, (1962) · [Zbl 0102.20704](#)
- [15] Tetrode, H., Über den wirkungszusammenhang der welt. eine erweiterung der klassischen dynamik, Z. Phys., 10, 317, (1922)
- [16] Fokker, A., Ein invarianter variationsatz für die bewegung mehrerer elektrischer massenteilchen, Z. Phys., 58, 386, (1929) · [Zbl 55.0522.03](#)
- [17] Ramond, P., Action-at-a-distance and dual models, Phys. Rev., D 7, 449, (1973)
- [18] Kalb, M.; Ramond, P., Classical direct interstring action, Phys. Rev., D 9, 2273, (1974)

- [19] Letelier, PS, Classic theory of direct intermembrane interaction, *J. Math. Phys.*, 17, 923, (1976)
- [20] Letelier, PS, Gauge invariant theory of direct interaction between membranes, *Phys. Rev.*, D 16, 322, (1977)
- [21] Nepomechie, RI; Rubin, MA; Hosotani, Y., A new formulation of the string action, *Phys. Lett.*, B 105, 457, (1981)
- [22] Baker, M.; Steinke, R., Effective string theory of vortices and Regge trajectories, *Phys. Rev.*, D 63, 094013, (2001)
- [23] Katz, A., Alternative dynamics for classical relativistic particles, *J. Math. Phys.*, 10, 1929, (1969)
- [24] Katz, A., Relativistic effects of strong binding on slow particles, *J. Math. Phys.*, 10, 2215, (1969)
- [25] Önem, C., The classical relativistic two-body problem with self-interaction, *Nuovo Cim.*, B 110, 943, (1995)
- [26] Dam, H.; Wigner, EP, Classical relativistic mechanics of interacting point particles, *Phys. Rev.*, 138, b1576, (1965) · [Zbl 0128.45201](#)
- [27] Dettman, JW; Schild, A., Conservation theorems in modified electrodynamics, *Phys. Rev.*, 95, 1057, (1954) · [Zbl 0057.44302](#)
- [28] E.C.G. Sudarshan and N. Mukunda, *Classical Dynamics: A modern perspective*, Wiley (1974), ch. 22. · [Zbl 0329.70001](#)
- [29] A. Barut, *Electrodynamics and classical theory of fields and particles*, Dover (1980).
- [30] Dirac, PAM, The theory of magnetic poles, *Phys. Rev.*, 74, 817, (1948) · [Zbl 0034.27604](#)
- [31] Dirac, PAM, Quantized singularities in the electromagnetic field, *Proc. Roy. Soc. Lond.*, A 133, 60, (1931) · [Zbl 0002.30502](#)
- [32] Brink, L.; Vecchia, P.; Howe, PS, A Lagrangian formulation of the classical and quantum dynamics of spinning particles, *Nucl. Phys.*, B 118, 76, (1977)
- [33] L. Moyaerts, K. Langfeld and H. Gies, *Worldline approach to the Casimir effect*, in proceedings of the *6th Workshop on Quantum Field Theory under the Influence of External Conditions*, Norman, U.S.A., 15-19 Sep 2003, pp. 203-211 [hep-th/0311168] [INSPIRE].
- [34] Gies, H.; Langfeld, K.; Moyaerts, L., Casimir effect on the worldline, *JHEP*, 06, 018, (2003)
- [35] N. Ahmadiiaz, F. Bastianelli and O. Corradini, *Tree-level amplitudes in scalar QCD from the worldline formalism*, arXiv:1508.05144 [INSPIRE].
- [36] A.M. Polyakov, *Gauge fields and Strings*, Harwood Academic Publishers (1987).
- [37] Mansfield, P., String theory, *Rept. Prog. Phys.*, 53, 1183, (1990)
- [38] Dai, P.; Siegel, W., Worldline Green functions for arbitrary Feynman diagrams, *Nucl. Phys.*, B 770, 107, (2007) · [Zbl 1117.81107](#)
- [39] Barut, AO; Onem, C.; Unal, N., The classical relativistic two-body problem with spin and selfinteractions, *J. Phys.*, A 23, 1113, (1990) · [Zbl 0706.70021](#)
- [40] Barut, AO; Cruz, MG, Classical relativistic spinning particle with anomalous magnetic moment: the precession of spin, *J. Phys.*, A 26, 6499, (1993) · [Zbl 0809.53082](#)
- [41] V.V. Tugai and A.A. Zheltukhin, *Supersymmetric electrodynamics of charged and neutral fermions in the extended Wheeler-Feynman approach*, hep-th/9602128 [INSPIRE].
- [42] Weiss, J., Is there action-at-a-distance linear confinement?, *J. Math. Phys.*, 27, 1015, (1986)
- [43] Louis-Martinez, DJ, Relativistic action at a distance and fields, *Found. Phys.*, 42, 215, (2012) · [Zbl 1243.83013](#)
- [44] Feynman, RP, Mathematical formulation of the quantum theory of electromagnetic interaction, *Phys. Rev.*, 80, 440, (1950) · [Zbl 0040.28002](#)
- [45] L.E. Ibanez and A.M. Uranga, *String theory and particle physics: An introduction to string phenomenology*, Cambridge University Press (2012). · [Zbl 1260.81001](#)
- [46] Schwinger, JS, On gauge invariance and vacuum polarization, *Phys. Rev.*, 82, 664, (1951) · [Zbl 0043.42201](#)
- [47] Bern, Z.; Kosower, DA, The computation of loop amplitudes in gauge theories, *Nucl. Phys.*, B 379, 451, (1992)
- [48] Bern, Z., A compact representation of the one-loop N-gluon amplitude, *Phys. Lett.*, B 296, 85, (1992)
- [49] Bern, Z.; Kosower, DA, Efficient calculation of one-loop QCD amplitudes, *Phys. Rev. Lett.*, 66, 1669, (1991)
- [50] Bern, Z.; Kosower, DA, Color decomposition of one-loop amplitudes in gauge theories, *Nucl. Phys.*, B 362, 389, (1991)
- [51] Dai, P.; Huang, Y-t; Siegel, W., Worldgraph approach to Yang-Mills amplitudes from N = 2 spinning particle, *JHEP*, 10, 027, (2008) · [Zbl 1245.81286](#)
- [52] Hawking, S., Zeta function regularization of path integrals in curved space-time, *Commun. Math. Phys.*, 55, 133, (1977) · [Zbl 0407.58024](#)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.