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The Dark Sectors Library

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Abstract: This is meant to be a *living* document whose purpose is to make it easier to find and/or appropriately cite the growing vast literature on dark-sector physics. Below, we provide citation blocks for various categories of work. Anybody is free to download the LaTeX file used to produce this PDF file—and the corresponding BibTeX file—both of which are provided on https://gitlab.com/philten/darkcast. We know that this document does not yet live up to its lofty title. Please send suggested updates via email to one of the authors listed above, or preferred, edit these files yourself and submit a merge request to our https://gitlab.com/philten/darkcast page!

Below is the list of references, roughly categorized as follows (admittedly, this categorization is not perfect; help us improve it by committing a merge request):

– foundational A' theory work [1–6];

– community reports [7–9];

– constraints on visible A' decays from beam-dump experiments [6, 10–28];

  - limits from E141 [12], E137 [13], E774 [14], KEK [11], Orsay [15] set in Refs. [6, 23];
  - limits from ν-CAL I [24, 25] set in Refs. [20, 22];
  - limits from CHARM [26] set in Ref. [21];
  - limits from NOMAD [17] and PS191 [27] set in Ref. [28];

– constraints on visible A' decays from fixed-target experiments [29–31];

  - A1 [30] and APEX [29];

– constraints on visible A' decays from collider experiments [32–38];

  - BaBar [34];
  - KLOE [37, 38];
  - LHCb [36];

– constraints on visible A' decays rare-meson-decay experiments [27, 28, 37–44];

  - NA48/2 [44];

– constraints on invisible A' decays [45–52];

  - from NA64 [52];
  - from BaBar [48].

– proposed searches for dark photons [53–69];

– A'–Z mixing [70–72];

– enhancement of longitudinal modes for anomalous currents (*e.g.* baryon number) [73–75], and constraints that arise from the requirement of anomaly cancellation [76];

– constraints on $B - L$ [77–81]:

  - from A' searches set in Ref. [81] and elsewhere;
  - from Borexino [77] set in Ref. [78];
  - from SPEAR, DORIS, and PETRA [79] set in Ref. [80].

– constraints on and proposed searches for the B (baryon number) boson [73, 74, 76, 81–93]:

  - from Υ decays [82] set in Ref. [83];
  - from η decays [84] set in Ref. [85];
  - from longitudinal-mode enhancements [73, 74] in $B_{u,d} \to KX$ [86–88], $K \to \pi X$ [89, 90], and $Z \to X\gamma$ [91, 92] processes (the constraints from Refs. [87, 88] were set in Ref. [81]);
  - inferred due to the lack of observed new anomaly-canceling fermions [76];
  - from A' searches set in Ref. [81] and elsewhere;
  - and proposed searches [93].

– protophobic forces [94];

– constraints on A' from $(g-2)_e$ [95, 96];

– searches for $B_{u,d} \to K^{(*)}X$ with $X \to \mu^+\mu^-$ [87, 88];

– and some non-vector proposals [97, 98].

N.b., anybody who submits an accepted merge request can add themselves as an author to this document if they choose to do so.

References

[1] L. B. Okun, *Limits of electrodynamcis: Paraphotons?*, *Sov. Phys. JETP* **56** (1982) 502.

[2] P. Galison and A. Manohar, *Two Z's or not two Z's?*, *Phys. Lett.* **B136** (1984) 279.

[3] B. Holdom, *Two $U(1)$'s and ϵ charge shifts*, *Phys. Lett.* **B166** (1986) 196.

[4] M. Pospelov, A. Ritz and M. B. Voloshin, *Secluded WIMP dark matter*, *Phys. Lett.* **B662** (2008) 53–61, [0711.4866].

[5] N. Arkani-Hamed, D. P. Finkbeiner, T. R. Slatyer and N. Weiner, *A theory of dark matter*, *Phys. Rev.* **D79** (2009) 015014, [0810.0713].

[6] J. D. Bjorken, R. Essig, P. Schuster and N. Toro, *New fixed-target experiments to search for dark gauge forces*, *Phys. Rev.* **D80** (2009) 075018, [0906.0580].

[7] R. Essig et al., *Working Group Report: New Light Weakly Coupled Particles*, in *Proceedings, 2013 Community Summer Study on the Future of U.S. Particle Physics: Snowmass on the Mississippi (CSS2013): Minneapolis, MN, USA, July 29-August 6, 2013*, 2013, 1311.0029, https://inspirehep.net/record/1263039/files/arXiv:1311.0029.pdf.

[8] J. Alexander et al., *Dark Sectors 2016 Workshop: Community Report*, 2016, 1608.08632, http://inspirehep.net/record/1484628/files/arXiv:1608.08632.pdf.

[9] M. Battaglieri et al., *US Cosmic Visions: New Ideas in Dark Matter 2017: Community Report*, 1707.04591.

[10] CHARM collaboration, F. Bergsma et al., *A search for decays of heavy neutrinos in the mass range 0.5 GeV to 2.8 GeV*, *Phys. Lett.* **B166** (1986) 473.

[11] A. Konaka et al., *Search for neutral particles in electron-beam-dump experiment*, *Phys. Rev. Lett.* **57** (1986) 659.

[12] E. M. Riordan et al., *Search for short-lived axions in an electron-beam-dump experiment*, *Phys. Rev. Lett.* **59** (1987) 755.

[13] J. D. Bjorken, S. Ecklund, W. R. Nelson, A. Abashian, C. Church, B. Lu et al., *Search for neutral metastable penetrating particles produced in the SLAC beam dump*, *Phys. Rev.* **D38** (1988) 3375.

[14] A. Bross, M. Crisler, S. H. Pordes, J. Volk, S. Errede and J. Wrbanek, *A search for short-lived particles produced in an electron beam dump*, *Phys. Rev. Lett.* **67** (1991) 2942–2945.

[15] M. Davier and H. Nguyen Ngoc, *An unambiguous search for a light Higgs boson*, *Phys. Lett.* **B229** (1989) 150.

[16] LSND collaboration, C. Athanassopoulos et al., *Evidence for $\nu_\mu \to \nu_e$ oscillations from pion decay in flight neutrinos*, *Phys. Rev.* **C58** (1998) 2489–2511, [nucl-ex/9706006].

[17] NOMAD collaboration, P. Astier et al., *Search for heavy neutrinos mixing with tau neutrinos*, *Phys. Lett.* **B506** (2001) 27–38, [hep-ex/0101041].

[18] R. Essig, R. Harnik, J. Kaplan and N. Toro, *Discovering new light states at neutrino experiments*, *Phys. Rev.* **D82** (2010) 113008, [1008.0636].

[19] M. Williams, C. P. Burgess, A. Maharana and F. Quevedo, *New Constraints (and Motivations) for Abelian Gauge Bosons in the MeV-TeV Mass Range*, *JHEP* **08** (2011) 106, [1103.4556].

[20] J. Blümlein and J. Brunner, *New exclusion limits for dark gauge forces from beam-dump data*, *Phys. Lett.* **B701** (2011) 155–159, [1104.2747].

[21] S. Gninenko, *Constraints on sub-GeV hidden sector gauge bosons from a search for heavy neutrino decays*, *Phys. Lett.* **B713** (2012) 244–248, [1204.3583].

[22] J. Blümlein and J. Brunner, *New exclusion limits on dark gauge forces from proton bremsstrahlung in beam-dump data*, *Phys. Lett.* **B731** (2014) 320–326, [1311.3870].

[23] S. Andreas, C. Niebuhr and A. Ringwald, *New Limits on Hidden Photons from Past Electron Beam Dumps*, *Phys. Rev.* **D86** (2012) 095019, [1209.6083].

[24] J. Blümlein et al., *Limits on neutral light scalar and pseudoscalar particles in a proton beam dump experiment*, *Z. Phys.* **C51** (1991) 341–350.

[25] J. Blümlein et al., *Limits on the mass of light (pseudo)scalar particles from Bethe-Heitler e^+e^- and $\mu^+\mu^-$ pair production in a proton-iron beam dump experiment*, *Int. J. Mod. Phys.* **A7** (1992) 3835–3850.

[26] CHARM collaboration, F. Bergsma et al., *Search for Axion Like Particle Production in 400-GeV Proton - Copper Interactions*, *Phys. Lett.* **157B** (1985) 458–462.

[27] G. Bernardi et al., *Search for neutrino decay*, *Phys. Lett.* **B166** (1986) 479.

[28] S. Gninenko, *Stringent limits on the $\pi^0 \to \gamma X, X \to e^+e^-$ decay from neutrino experiments and constraints on new light gauge bosons*, *Phys. Rev.* **D85** (2012) 055027, [1112.5438].

[29] APEX collaboration, S. Abrahamyan et al., *Search for a new gauge boson in electron-nucleus fixed-target scattering by the APEX experiment*, *Phys. Rev. Lett.* **107** (2011) 191804, [1108.2750].

[30] A1 collaboration, H. Merkel et al., *Search at the Mainz Microtron for light massive gauge bosons relevant for the muon g-2 anomaly*, *Phys. Rev. Lett.* **112** (2014) 221802, [1404.5502].

[31] A1 collaboration, H. Merkel et al., *Search for light gauge bosons of the dark sector at the Mainz Microtron*, *Phys. Rev. Lett.* **106** (2011) 251802, [1101.4091].

[32] BaBar collaboration, B. Aubert et al., *Search for dimuon decays of a light scalar boson in radiative transitions* $\Upsilon \to \gamma A^0$, *Phys. Rev. Lett.* **103** (2009) 081803, [0905.4539].

[33] D. Curtin et al., *Exotic decays of the 125 GeV Higgs boson*, *Phys. Rev.* **D90** (2014) 075004, [1312.4992].

[34] BaBar collaboration, J. P. Lees et al., *Search for a dark photon in* e^+e^- *collisions at BaBar*, *Phys. Rev. Lett.* **113** (2014) 201801, [1406.2980].

[35] BESIII collaboration, M. Ablikim et al., *Dark photon search in the mass range between 1.5 and 3.4* GeV/c^2, 1705.04265.

[36] LHCb collaboration, R. Aaij et al., *Search for dark photons produced in 13 TeV pp collisions*, 1710.02867.

[37] KLOE-2 collaboration, F. Archilli et al., *Search for a vector gauge boson in* ϕ *meson decays with the KLOE detector*, *Phys. Lett.* **B706** (2012) 251–255, [1110.0411].

[38] KLOE-2 collaboration, A. Anastasi et al., *Limit on the production of a new vector boson in* $e^+e^- \to U\gamma$, $U \to \pi^+\pi^-$ *with the KLOE experiment*, *Phys. Lett.* **B757** (2016) 356–361, [1603.06086].

[39] SINDRUM I collaboration, R. Meijer Drees et al., *Search for weakly interacting neutral bosons produced in* $\pi^- p$ *interactions at rest and decaying into* e^+e^- *pairs*, *Phys. Rev. Lett.* **68** (1992) 3845–3848.

[40] KLOE-2 collaboration, D. Babusci et al., *Limit on the production of a light vector gauge boson in* ϕ *meson decays with the KLOE detector*, *Phys. Lett.* **B720** (2013) 111–115, [1210.3927].

[41] WASA-at-COSY collaboration, P. Adlarson et al., *Search for a dark photon in the* $\pi^0 \to e^+e^-\gamma$ *decay*, *Phys. Lett.* **B726** (2013) 187–193, [1304.0671].

[42] HADES collaboration, G. Agakishiev et al., *Searching for a dark photon with HADES*, *Phys. Lett.* **B731** (2014) 265–271, [1311.0216].

[43] PHENIX collaboration, A. Adare et al., *Search for dark photons from neutral meson decays in pp and dAu collisions at* $\sqrt{s_{NN}} = 200$ *GeV*, *Phys. Rev.* **C91** (2015) 031901, [1409.0851].

[44] NA48/2 collaboration, J. R. Batley et al., *Search for the dark photon in* π^0 *decays*, *Phys. Lett.* **B746** (2015) 178–185, [1504.00607].

[45] R. Essig, J. Mardon, M. Papucci, T. Volansky and Y.-M. Zhong, *Constraining Light Dark Matter with Low-Energy* e^+e^- *Colliders*, *JHEP* **11** (2013) 167, [1309.5084].

[46] H. Davoudiasl, H.-S. Lee and W. J. Marciano, *Muon* $g-2$*, rare kaon decays, and parity violation from dark bosons*, *Phys. Rev.* **D89** (2014) 095006, [1402.3620].

[47] NA64 collaboration, D. Banerjee et al., *Search for invisible decays of sub-GeV dark photons in missing-energy events at the CERN SPS*, *Phys. Rev. Lett.* **118** (2017) 011802, [1610.02988].

[48] BaBar collaboration, J. P. Lees et al., *Search for Invisible Decays of a Dark Photon Produced in* e^+e^- *Collisions at BaBar*, *Phys. Rev. Lett.* **119** (2017) 131804, [1702.03327].

[49] E787 collaboration, S. Adler et al., *Further evidence for the decay $K^+ \to \pi^+ \nu\bar{\nu}$*, *Phys. Rev. Lett.* **88** (2002) 041803, [hep-ex/0111091].

[50] E787 collaboration, S. Adler et al., *Further search for the decay $K^+ \to \pi^+ \nu\bar{\nu}$ in the momentum region $p < 195$ MeV/c*, *Phys. Rev.* **D70** (2004) 037102, [hep-ex/0403034].

[51] BNL-E949 collaboration, A. V. Artamonov et al., *Study of the decay $K^+ \to \pi^+ \nu\bar{\nu}$ in the momentum region $140 < P_\pi < 199$ MeV/c*, *Phys. Rev.* **D79** (2009) 092004, [0903.0030].

[52] NA64 collaboration, D. Banerjee et al., *Search for vector mediator of Dark Matter production in invisible decay mode*, 1710.00971.

[53] R. Essig, P. Schuster, N. Toro and B. Wojtsekhowski, *An electron fixed target experiment to search for a new vector boson A' decaying to e^+e^-*, *JHEP* **02** (2011) 009, [1001.2557].

[54] M. Freytsis, G. Ovanesyan and J. Thaler, *Dark force detection in low energy ep collisions*, *JHEP* **01** (2010) 111, [0909.2862].

[55] J. Balewski et al., *DarkLight: A search for dark forces at the Jefferson Laboratory Free-Electron Laser facility*, 1307.4432.

[56] B. Wojtsekhowski, D. Nikolenko and I. Rachek, *Searching for a new force at VEPP-3*, 1207.5089.

[57] T. Beranek, H. Merkel and M. Vanderhaeghen, *Theoretical framework to analyze searches for hidden light gauge bosons in electron scattering fixed target experiments*, *Phys. Rev.* **D88** (2013) 015032, [1303.2540].

[58] M. Raggi and V. Kozhuharov, *Proposal to Search for a Dark Photon in Positron on Target Collisions at DAΦNE Linac*, *Adv. High Energy Phys.* **2014** (2014) 959802, [1403.3041].

[59] B. Echenard, R. Essig and Y.-M. Zhong, *Projections for dark photon searches at Mu3e*, *JHEP* **01** (2015) 113, [1411.1770].

[60] M. Battaglieri et al., *The Heavy Photon Search test detector*, *Nucl. Instrum. Meth.* **A777** (2015) 91–101, [1406.6115].

[61] S. Alekhin et al., *A facility to Search for Hidden Particles at the CERN SPS: the SHiP physics case*, 1504.04855.

[62] S. Gardner, R. J. Holt and A. S. Tadepalli, *New prospects in fixed target searches for dark forces with the SeaQuest experiment at Fermilab*, *Phys. Rev.* **D93** (2016) 115015, [1509.00050].

[63] P. Ilten, J. Thaler, M. Williams and W. Xue, *Dark photons from charm mesons at LHCb*, *Phys. Rev.* **D92** (2015) 115017, [1509.06765].

[64] D. Curtin, R. Essig, S. Gori and J. Shelton, *Illuminating dark photons with high-energy colliders*, *JHEP* **02** (2015) 157, [1412.0018].

[65] M. He, X.-G. He and C.-K. Huang, *Dark photon search at a circular e^+e^- collider*, *Int. J. Mod. Phys.* **A32** (2017) 1750138, [1701.08614].

[66] J. Kozaczuk, *Dark photons from nuclear transitions*, 1708.06349.

[67] P. Ilten, Y. Soreq, J. Thaler, M. Williams and W. Xue, *Proposed inclusive dark photon search at LHCb*, *Phys. Rev. Lett.* **116** (2016) 251803, [1603.08926].

[68] J. Feng, I. Galon, F. Kling and S. Trojanowski, *FASER: ForwArd Search ExpeRiment at the LHC*, 1708.09389.

[69] J. Alexander, *MMAPS: Missing-Mass A-Prime Search*, *EPJ Web Conf.* **142** (2017) 01001.

[70] G. Barello, S. Chang and C. A. Newby, *Correlated signals at the energy and intensity frontiers from non-Abelian kinetic mixing*, *Phys. Rev.* **D94** (2016) 055018, [1511.02865].

[71] S. Cassel, D. M. Ghilencea and G. G. Ross, *Electroweak and Dark Matter Constraints on a Z-prime in Models with a Hidden Valley*, *Nucl. Phys.* **B827** (2010) 256–280, [0903.1118].

[72] J. M. Cline, G. Dupuis, Z. Liu and W. Xue, *The windows for kinetically mixed Z'-mediated dark matter and the galactic center gamma ray excess*, *JHEP* **08** (2014) 131, [1405.7691].

[73] J. A. Dror, R. Lasenby and M. Pospelov, *Dark forces coupled to nonconserved currents*, *Phys. Rev.* **D96** (2017) 075036, [1707.01503].

[74] J. A. Dror, R. Lasenby and M. Pospelov, *New constraints on light vectors coupled to anomalous currents*, *Phys. Rev. Lett.* **119** (2017) 141803, [1705.06726].

[75] A. Ismail and A. Katz, *Anomalous Z' and Diboson Resonances at the LHC*, 1712.01840.

[76] B. A. Dobrescu and C. Frugiuele, *Hidden GeV-scale interactions of quarks*, *Phys. Rev. Lett.* **113** (2014) 061801, [1404.3947].

[77] G. Bellini et al., *Precision measurement of the 7Be solar neutrino interaction rate in Borexino*, *Phys. Rev. Lett.* **107** (2011) 141302, [1104.1816].

[78] R. Harnik, J. Kopp and P. A. N. Machado, *Exploring ν Signals in Dark Matter Detectors*, *JCAP* **1207** (2012) 026, [1202.6073].

[79] E. D. Carlson, *Limits on a new U(1) coupling*, *Nucl. Phys.* **B286** (1987) 378–398.

[80] C. Frugiuele, E. Fuchs, G. Perez and M. Schlaffer, *Constraining New Physics Models with Isotope Shift Spectroscopy*, *Phys. Rev.* **D96** (2017) 015011, [1602.04822].

[81] P. Ilten, Y. Soreq, M. Williams and W. Xue, *Serendipity in dark photon searches*, 1801.04847.

[82] ARGUS collaboration, H. Albrecht et al., *An Upper Limit for Two Jet Production in Direct Υ (1s) Decays*, *Z. Phys.* **C31** (1986) 181.

[83] A. Aranda and C. D. Carone, *Limits on a light leptophobic gauge boson*, *Phys. Lett.* **B443** (1998) 352–358, [hep-ph/9809522].

[84] S. Prakhov et al., *Measurement of the invariant-mass spectrum for the two photons from the $\eta \to \pi^0\gamma\gamma$ decay*, *Phys. Rev.* **C78** (2008) 015206.

[85] S. Tulin, *New weakly-coupled forces hidden in low-energy QCD*, *Phys. Rev.* **D89** (2014) 114008, [1404.4370].

[86] Belle collaboration, J. Grygier et al., *Search for $B \to h\nu\bar{\nu}$ decays with semileptonic tagging at Belle*, *Phys. Rev.* **D96** (2017) 091101, [1702.03224].

[87] LHCb collaboration, R. Aaij et al., *Search for hidden-sector bosons in $B^0 \to K^{*0}\mu^+\mu^-$ decays*, *Phys. Rev. Lett.* **115** (2015) 161802, [1508.04094].

[88] LHCb collaboration, R. Aaij et al., *Search for long-lived scalar particles in $B^+ \to K^+\chi(\mu^+\mu^-)$ decays*, *Phys. Rev.* **D95** (2017) 071101, [1612.07818].

[89] KTeV collaboration, A. Alavi-Harati et al., *Search for the rare decay $K_L \to \pi^0 e^+ e^-$*, *Phys. Rev. Lett.* **93** (2004) 021805, [hep-ex/0309072].

[90] E949 collaboration, A. V. Artamonov et al., *New measurement of the $K^+ \to \pi^+ \nu\bar{\nu}$ branching ratio*, *Phys. Rev. Lett.* **101** (2008) 191802, [0808.2459].

[91] L3 collaboration, M. Acciarri et al., *Search for new physics in energetic single photon production in e^+e^- annihilation at the Z resonance*, *Phys. Lett.* **B412** (1997) 201–209.

[92] DELPHI collaboration, P. Abreu et al., *Search for neutral heavy leptons produced in Z decays*, *Z. Phys.* **C74** (1997) 57–71.

[93] C. Fanelli and M. Williams, *Photoproduction of leptophobic bosons*, *J. Phys.* **G44** (2017) 014002, [1605.07161].

[94] J. L. Feng, B. Fornal, I. Galon, S. Gardner, J. Smolinsky, T. M. P. Tait et al., *Particle physics models for the 17 MeV anomaly in beryllium nuclear decays*, *Phys. Rev.* **D95** (2017) 035017, [1608.03591].

[95] M. Pospelov, *Secluded U(1) below the weak scale*, *Phys. Rev.* **D80** (2009) 095002, [0811.1030].

[96] M. Endo, K. Hamaguchi and G. Mishima, *Constraints on Hidden Photon Models from Electron g-2 and Hydrogen Spectroscopy*, *Phys. Rev.* **D86** (2012) 095029, [1209.2558].

[97] Y. Kahn, G. Krnjaic, S. Mishra-Sharma and T. M. P. Tait, *Light Weakly Coupled Axial Forces: Models, Constraints, and Projections*, *JHEP* **05** (2017) 002, [1609.09072].

[98] U. Haisch and J. F. Kamenik, *Searching for new spin-0 resonances at LHCb*, *Phys. Rev.* **D93** (2016) 055047, [1601.05110].