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Experimental frontiers: complementarity and dark photon benchmarks

Despite the proven success of the Standard Model, with a history of discoveries confirming its predictions, it is well known that it is not a complete theory. The model is deficient in its ability to answer a number of questions that nature has posed; a leading question among these is about the composition of the vast majority of the matter in our universe.

Beginning from the well motivated supposition that there do exist non gravitational, particulate interactions between dark matter and standard matter, the current relic abundance can be recovered by a variety of models, accessible by a wide range of experiments, on complementary research frontiers.

One versatile model, covering a range of so far unprobed parameter space, are 'vector portal' models. Specifically in the case of this work, minimal dark photon models are investigated, which are a first step toward ruling out those areas of parameter space that are most easily accessible. The coupling to the standard model is in the form of a kinetic term in the lagrangian which arises after the introduction of a new abelian U(1) gauge field. This extra U(1) symmetry introduces only two new particles, the dark matter itself and a dark vector mediator, which undergoes kinetic mixing with the standard photon, or with the Z boson.

The world of collision experiments, the energy frontier, can reach higher energies than the realm of the intensity frontier, which can reach higher sensitivities to lower couplings. In combination with the cosmological frontier, comprising of direct and indirect detection experiments without the need for an accelerator, these frontiers are fundamentally complementary. Exclusion plots showing detectable limits for masses and couplings, showing forecasts from experiments of different frontiers, can facilitate cross frontier discussions about research goals in the future.

The focus here is on the connection between minimal vector and dark photon mediated models specifically, attempting to rescale limits we currently have to dark photon model limits. An additional aim is to extend energy frontier projections to scenarios with arbitrarily low couplings from the intensity frontier.

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