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Nondecoupling Signatures of Supersymmetry and an Lμ-Lτ Gauge Boson at Belle-II

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Abstract : Supersymmetry, one of the most celebrated fields of study for explaining experimental observations where the standard model (SM) falls short, is reeling from the lack of experimental vindication. At the same time, the idea of additional gauge symmetry, in particular, the gauged Lμ-Lτ symmetric models have also generated significant interest. They have been extensively proposed in order to explain the tantalizing discrepancy in the predicted and measured value of the muon anomalous magnetic moment alongside several other issues plaguing the SM. While very little parameter space within these models remain unconstrained, this work finds that the γ + Missing Energy (ME) signal at the Belle-II detector will be a smoking gun for supersymmetry (SUSY) in the presence of a gauged U(1)Lμ-Lτ symmetry. A remarkable consequence of breaking the enhanced symmetry appearing in the limit of degenerate (s)leptons is the nondecoupling of the radiative contribution of heavy charged sleptons to the γ-Z′ kinetic mixing. The signal process, $e^+e^- \to \gamma Z' \to \gamma$+ME, is an outcome of this ubiquitous feature. Taking the severe constraints on gauged Lμ-Lτ models by several low energy observables into account, it is shown that any significant excess in all but the highest photon energy bin would be an undeniable signature of such heavy scalar fields in SUSY coupling to the additional gauge boson Z′. The number of signal events depends crucially on the logarithm of the ratio of stau to smuon mass in the presence of SUSY. In addition, the number is also inversely proportional to the e^+e^- collision energy, making a low-energy, high-luminosity collider like Belle-II an ideal testing ground for this channel. This process can probe large swathes of the hitherto free slepton mass ratio vs. additional gauge coupling (g_x) parameter space. More importantly, it can explore the narrow slice of Z′ mass (MZ′) vs. g_x parameter space still allowed in gauged U(1)Lμ-Lτ models for superheavy sparticles. The spectacular finding that the signal significance is independent of individual slepton masses is an exciting prospect indeed. Further, the prospect that signatures of even superheavy SUSY particles that may have escaped detection at the LHC may show up at the Belle-II detector is an invigorating revelation.

Keywords : additional gauge symmetry, electron-positron collider, kinetic mixing, nondecoupling radiative effect, supersymmetry
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