

Search for a heavy dark photon at future e^+e^- colliders

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A coupling of a dark photon A' from a $U(1)_{A'}$ with the standard model (SM) particles can be generated through kinetic mixing represented by a parameter ϵ . A non-zero ϵ also induces a mixing between A' and Z if dark photon mass $m_{A'}$ is not zero. This mixing can be large when $m_{A'}$ is close to m_Z even if the parameter ϵ is small. Many efforts have been made to constrain the parameter ϵ for a low dark photon mass $m_{A'}$ compared with the Z boson mass m_Z . We study the search for dark photon in $e^+e^- \rightarrow \gamma A' \rightarrow \gamma \mu^+ \mu^-$ for a dark photon mass $m_{A'}$ as large as kinematically allowed at future e^+e^- colliders. For large $m_{A'}$, care should be taken to properly treat possible large mixing between A' and Z . We obtain sensitivities to the parameter ϵ for a wide range of dark photon mass at planned e^+e^- colliders, such as Circular Electron Positron Collider (CEPC), International Linear Collider (ILC) and Future Circular Collider (FCC-ee). For the dark photon mass 20 GeV

lessim $m_{A'}$

lessim 330 GeV, the 2σ exclusion limits on the mixing parameter are ϵ

lessim $10^{-3} - 10^{-2}$. The CEPC with $\sqrt{s} = 240$ GeV and FCC-ee with $\sqrt{s} = 160$ GeV are more sensitive than the constraint from current LHCb measurement once the dark photon mass $m_{A'}$

gtrsim 50 GeV. For $m_{A'}$

gtrsim 220 GeV, the sensitivity at the FCC-ee with $\sqrt{s} = 350$ GeV and 1.5 ab^{-1} is better than that at the 13 TeV LHC with 300 fb^{-1} , while the sensitivity at the CEPC with $\sqrt{s} = 240$ GeV and 5 ab^{-1} can be even better than that at 13 TeV LHC with 3 ab^{-1} for $m_{A'}$

gtrsim 180 GeV. We also comment on sensitivities of $e^+e^- \rightarrow \gamma A'$ with dark photon decay into several other channels at future e^+e^- colliders.

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