Contribution ID: **170** Type: **parallel**

Search for dark photons in heavy-ion collisions

Tuesday 10 January 2023 15:10 (20 minutes)

Search for the dark matter (DM) candidates is one of the growing direction of the experimental and theoretical research in heavy-ion physics [1]. The vector □-bosons, or so called 'dark photons', are one of the possible candidates for the dark matter mediators. They are supposed to interact with the standard matter via a 'vector portal' due to the □(1)–□(1)′ symmetry group mixing which might make them visible in particle and heavy-ion experiments. While there is no confirmed observation of dark photons, the detailed analysis of different experimental data allows to estimate the upper limit for the kinetic mixing parameter □2 depending on the mass □□ of □-bosons which is also unknown.

In Ref. [2] we have introduced a procedure to define theoretical constraints on the upper limit of □2(□□) from heavy-ion (as well as □+□ and □+□) dilepton data. Our analysis is based on the microscopic Parton-Hadron-String Dynamics (PHSD) transport approach which reproduces well the measured dilepton spectra in □+□, □+□ and □+□ collisions. Additionally to the different dilepton channels originating from interactions and decays of ordinary (Standard Model) matter particles (mesons and baryons), we incorporate in the microscopic transport approach - for the first time - the decay of hypothetical □-bosons to dileptons, □⟶□+□−, where the □-bosons themselves are produced by the Dalitz decay of pions □0⟶□□, □-mesons □⟶□□ and Delta resonances Δ⟶□□.

Using the fact that dark photons are not observed in dilepton experiments so far one can require that their contribution can not exceed some limit which would make them visible in experimental data. By varying the parameter □2(□□) in the model calculations, one can obtain upper constraints on □2(□□) based on pure theoretical results for dilepton spectra under the constraint that the 'surplus' of the DM contribution doesn't overshine the SM contributions (which is equivalent to the measured dilepton spectra) with any requested accuracy. We confront our results with the analysis from the HADES Collaboration \cite{HADES:2013nab} at SIS18 energies where the dark photons are not observed as well as with the world data collection, including the LHC experimental results.

Our theoretical analysis can help to estimate the requested accuracy for future experimental searches of 'light' dark photons by dilepton experiments. Moreover, the extension of our procedure to other dark matter candidates - as axions - is foreseen.

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Session Classification: Parallel session C