INVISIBLES23

August 28 – September 01, Göttingen, Germany

Reconciliation of Secluded Dark Sector and Muon (g – 2) in the Light of Fast Expanding Universe

Ananya Tapadar

Based on: Sougata Ganguly, Sourov Roy, Ananya Tapadar, JCAP 02 (2023) 044 (arxiv:2208.13608)

Indian Association for the Cultivation of Science – Kolkata, India

Motivation

I. Dark Matter

II. Muon anomalous magnetic moment

Model

- Gauge theory of Model

$$SM \otimes U(1)_X \otimes U(1)_{L_\mu - L_\tau}$$

- The Lagrangian of our model :

kinetic mixing parameter

$$\mathscr{L} = \mathscr{L}_{SM} - \frac{1}{4}\hat{X}_{\rho\sigma}\hat{X}^{\rho\sigma} - \frac{1}{4}\hat{F}_{\mu\tau_{\rho\sigma}}\hat{F}^{\rho\sigma}_{\mu\tau} + \frac{\sin\delta}{2}\hat{X}_{\rho\sigma}\hat{F}^{\rho\sigma}_{\mu\tau} + \bar{\chi}(p_\mu \gamma^\mu - m_\chi)\chi$$
$$- g_X \bar{\chi}\gamma^\rho \chi \hat{Z}'_\rho - g_{\mu\tau}(\bar{\mu}\gamma_\rho \mu + \bar{\nu}_\mu \gamma_\rho P_L \nu_\mu - \bar{\tau}\gamma_\rho \tau + \bar{\nu}_\tau \gamma_\rho P_L \nu_\tau)\hat{Z}^\rho_{\mu\tau}$$
$$\frac{+1}{2}\hat{m}^2_{\mu\tau}\hat{Z}^\rho_{\mu\tau}\hat{Z}_{\mu\tau_\rho} + \frac{1}{2}\hat{m}'^2\hat{Z}'^\rho\hat{Z}'_\rho .$$

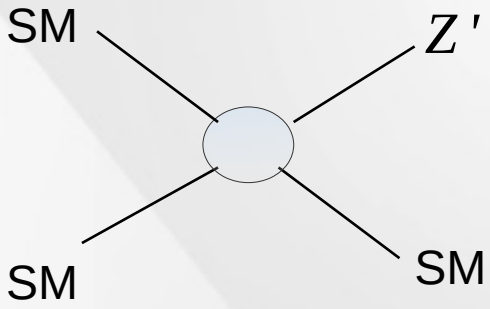
- After diagonalizing and rewriting the Lagrangian in mass basis,

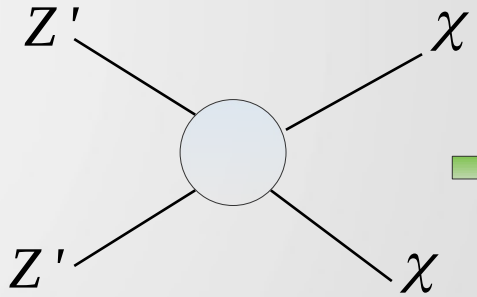
$$\mathcal{L} \supset -g_X \bar{\chi} \gamma^\rho \chi Z'_\rho - \epsilon \left(\bar{\mu} \gamma_\rho \mu + \bar{\nu}_\mu \gamma_\rho P_L \nu_\mu - \bar{\tau} \gamma_\rho \tau + \bar{\nu}_\tau \gamma_\rho P_L \nu_\tau \right) Z'_\rho$$

Assumption: $\frac{m_{Z'}}{m_{\mu\tau}}, \delta \ll 1$

$$g_{\mu\tau} \frac{m_{Z'}^2}{m_{\mu\tau}^2} \tan(\delta)$$

Dark sector formation,



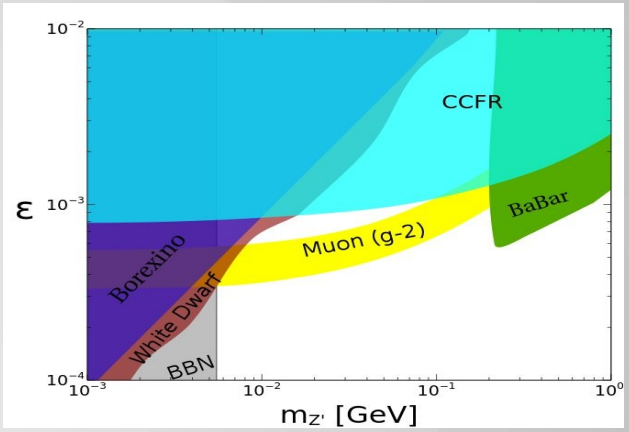


Dark Sector

$\chi \quad Z' \rightarrow T'$

Muon anomalous magnetic moment

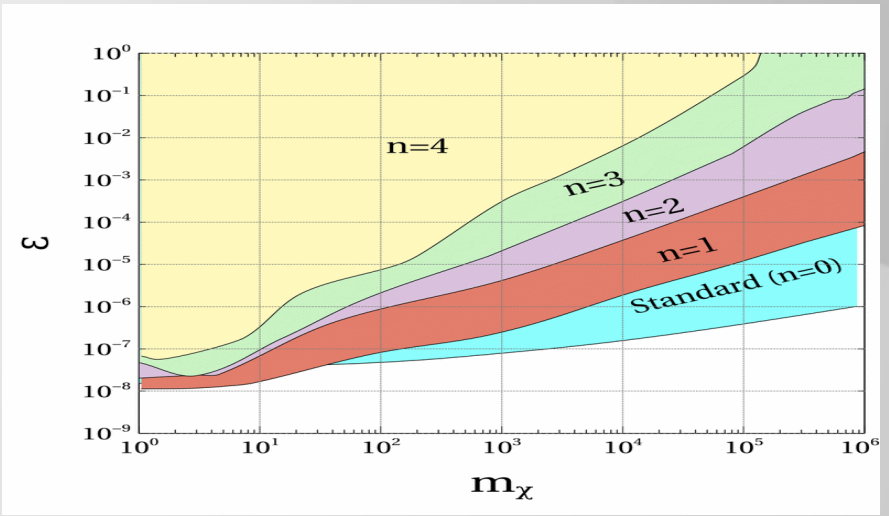
- In presence of light gauge boson (Z'), yellow region represents allowed parameter space for muon $(g-2)$.



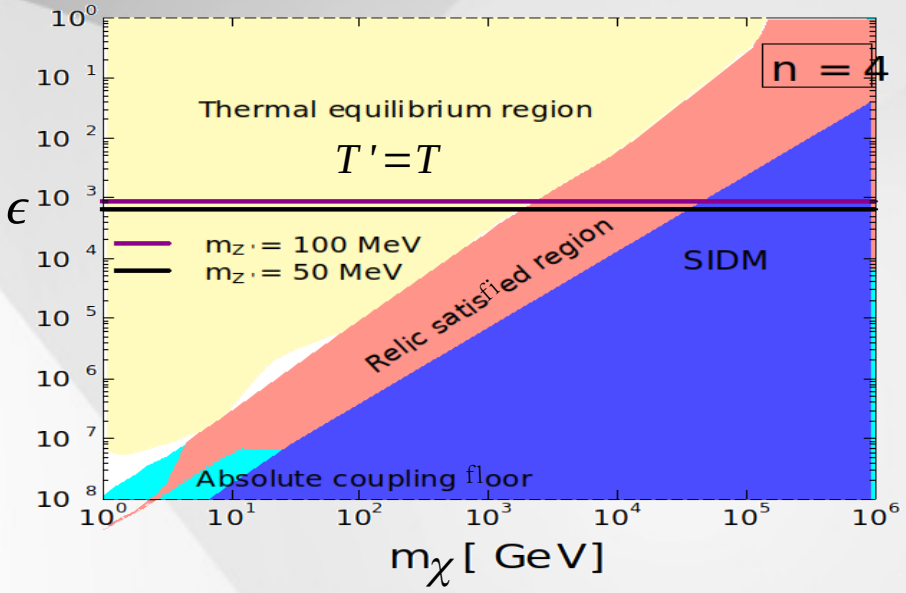
Single framework

- A new species ϕ and energy density of ϕ redshifts as $\rho_\phi \propto a^{-(n+4)}, n \geq 0$ where a is scale factor and n is expansion parameter.

- Shaded region represents thermal equilibrium region where DS and VS share same temperature.



Results



- Thermal equilibrium region

Dark sector temperature = Visible sector temperature

- Absolute coupling floor

Correct relic abundance of DM by dark sector freeze-out not possible.

- Relic satisfied region

1) Late time annihilation

2) Freeze-in

- Self interaction of DM

$$\chi\chi(\bar{\chi}) \rightarrow \chi\chi(\bar{\chi}) \,, \bar{\chi}\bar{\chi} \rightarrow \bar{\chi}\bar{\chi}$$

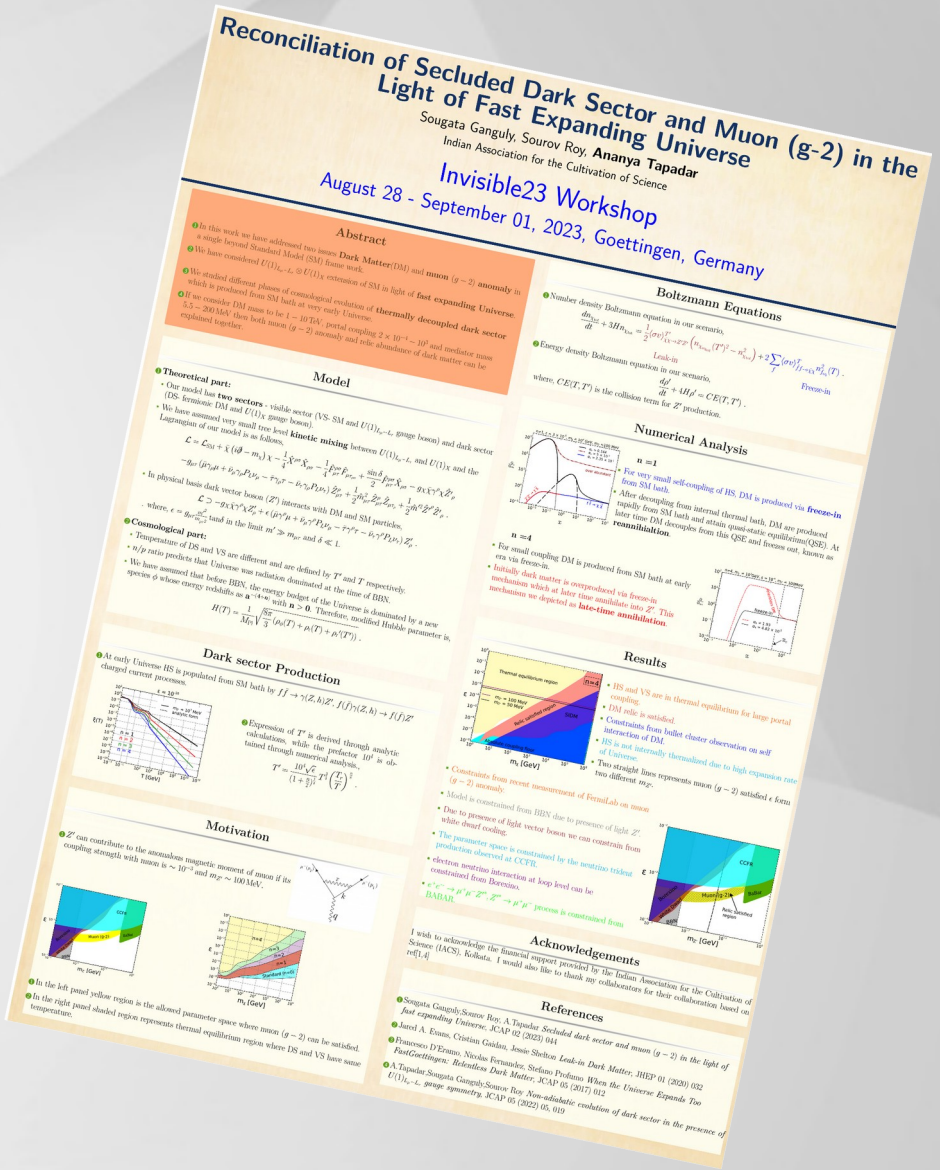
Galactic properties produced in N -body simulations.

Conclusion

1) If Universe expands at a faster rate than radiation then even after considering astrophysical ,cosmological and laboratory constraints DM phenomenology and muon (g-2) can be explained in a single framework.

2) The region of interest for $n=4$, is $1\,TeV \lesssim m_{\chi} \lesssim 10\,TeV$, $5.5\,MeV \lesssim m_{Z'} \lesssim 200\,MeV$ and $2\times10^{-4} \lesssim \epsilon \lesssim 10^{-3}$ where DM phenomenology and muon (g-2) can be explained in a single framework.

Thank you



Reconciliation of Secluded Dark Sector and Muon (g-2) in the Light of Fast Expanding Universe

Sougata Ganguly, Sourov Roy, **Ananya Tapadar**

Indian Association for the Cultivation of Science

Invisible23 Workshop

August 28 - September 01, 2023, Goettingen, Germany

Abstract

Model

Dark sector Production

Motivation

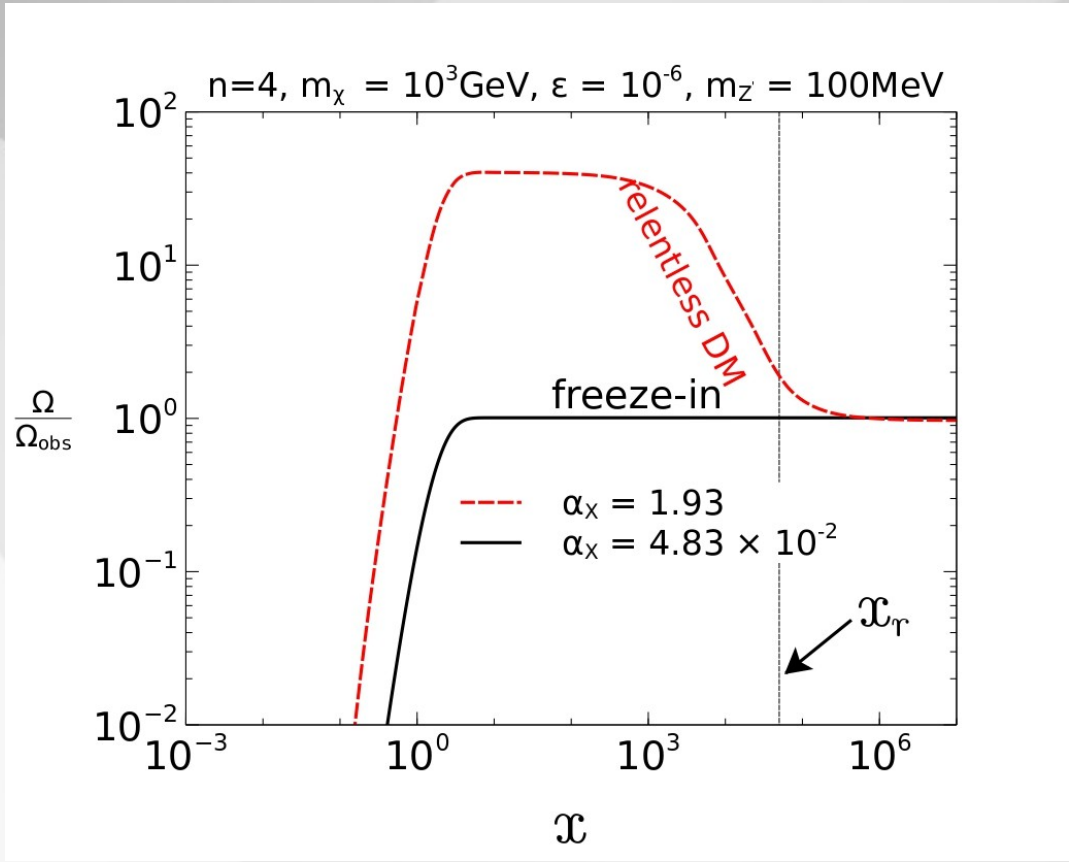
Boltzmann Equations

Numerical Analysis

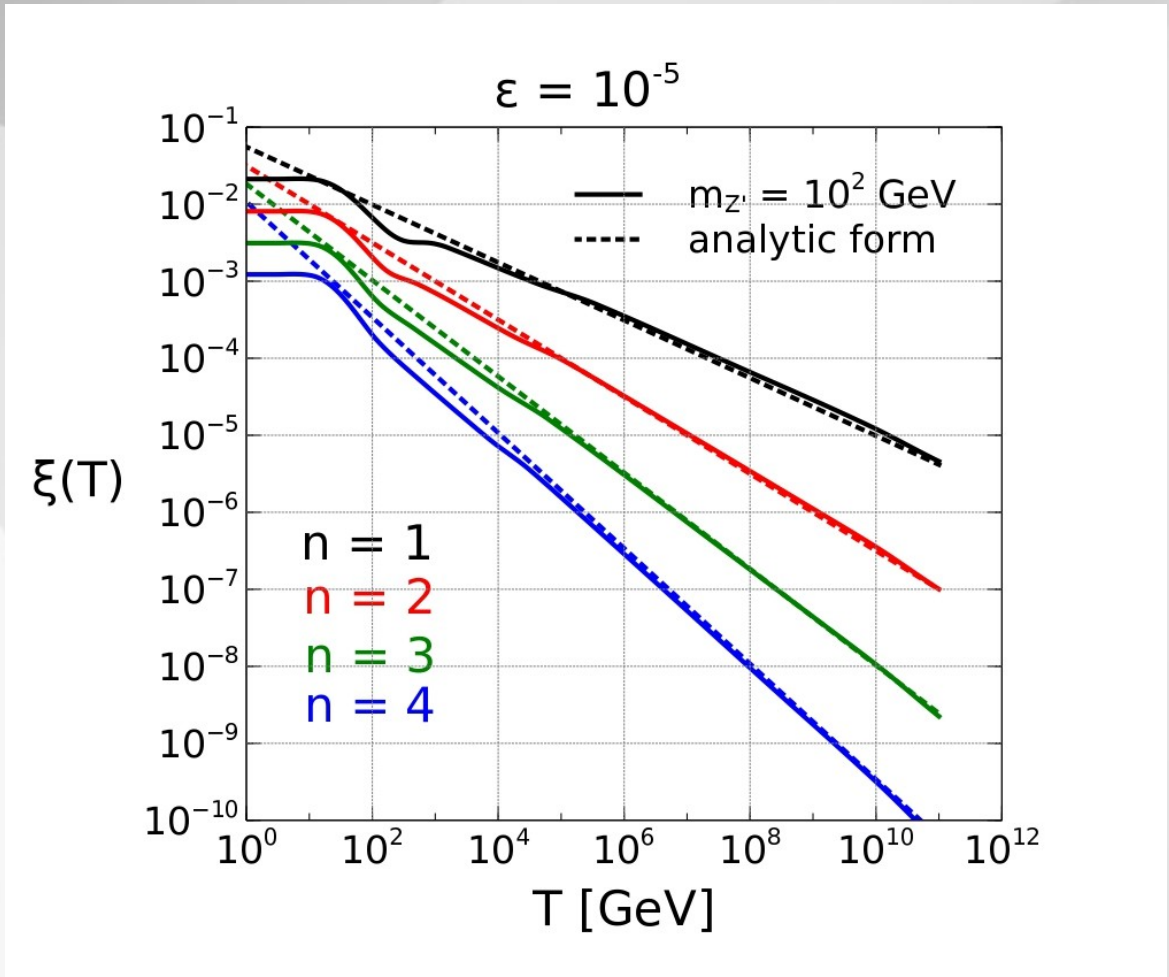
Results

Acknowledgements

References



$$\alpha_X = \frac{g_X^2}{4\pi}$$



$$\xi(T)=\frac{T'}{T}$$