Dark Matter with Monopoles

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Interests outside physics : 🧗, 🍳, 🍲

‘t Hooft & Polyakov monopole (1974)

Our model : $G = SO(3)_D \to H = SO(2)_D$, with a scalar triplet $\phi_a \sim \mathbf{3}$

$$\mathcal{L}_D = -\frac{1}{4} F_{a\mu\nu} F_a^{\mu\nu} + \frac{1}{2} D_\mu \phi_a D^\mu \phi_a + \frac{\mu^2}{2}\phi^2 - \frac{\lambda}{4}\phi^4$$

Three new parameters: $\{\lambda, g, \mu\} \Leftrightarrow \{\lambda, g, \eta\}$

Particle content: $(A'_\mu, m_{\gamma'} = 0)$; $(W'^{\pm}, m_{W'} = g\eta)$; $(\rho, m_\rho = \sqrt{2\lambda}\eta)$

And monopoles $M^{\pm m}$: $m_M \sim \frac{4\pi}{g}\eta, \quad r_M \sim \frac{1}{g\eta}$

Can monopoles account for the totality of Dark Matter ?

Two dark matter candidates: $M^{\pm_m}, \quad W'^{\pm}$

$\Rightarrow$ Scan through the parameter space to find a region where monopoles dominate the DM density

Monopoles are produced when the phase transition completes, and

$$n_M = p\xi^{-3}(t_{\text{prod}})$$

The precise value of $\xi(t_{\text{prod}})$ depends on the nature of the PT (SOFT, wFOPT, sFOPT).

$\rightarrow$ consider potential annihilations

$\rightarrow$ Compute and compare $\Omega_{W'}$ and Ω_M

Results

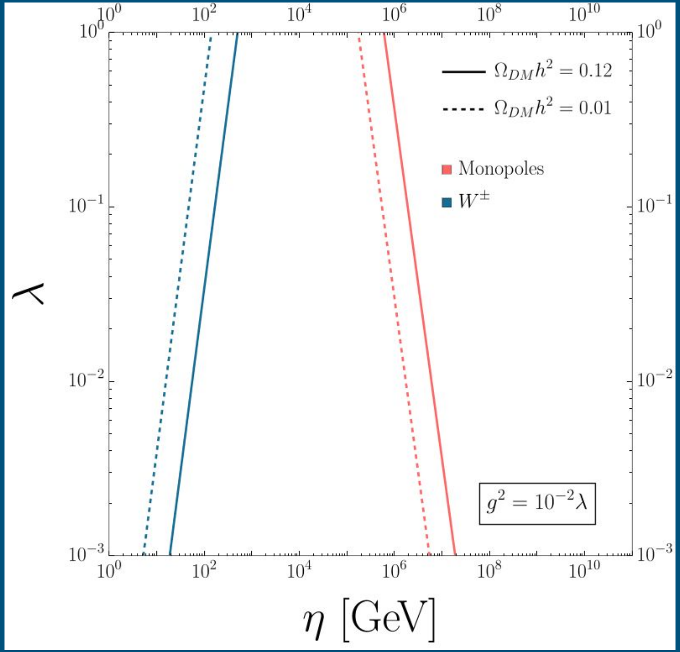
Example: SOPT $(\lambda \gg g^2)$

$$T_{\text{prod}} = T_c = \sqrt{\frac{12}{5}}\eta$$

$$\xi(t_{\text{prod}}) \simeq H^{-1}(T_c)\ [H(T_c)\xi_0]^{\frac{1}{1+\nu}} ,$$

where, $\xi_0 = m_\rho^{-1}$ and $\nu \simeq 0.7$

Zurek, 1985.



Thank you !