Neutralino dark matter stars can not exist

Speaker: De-Chang Dai

Physics Department of UB

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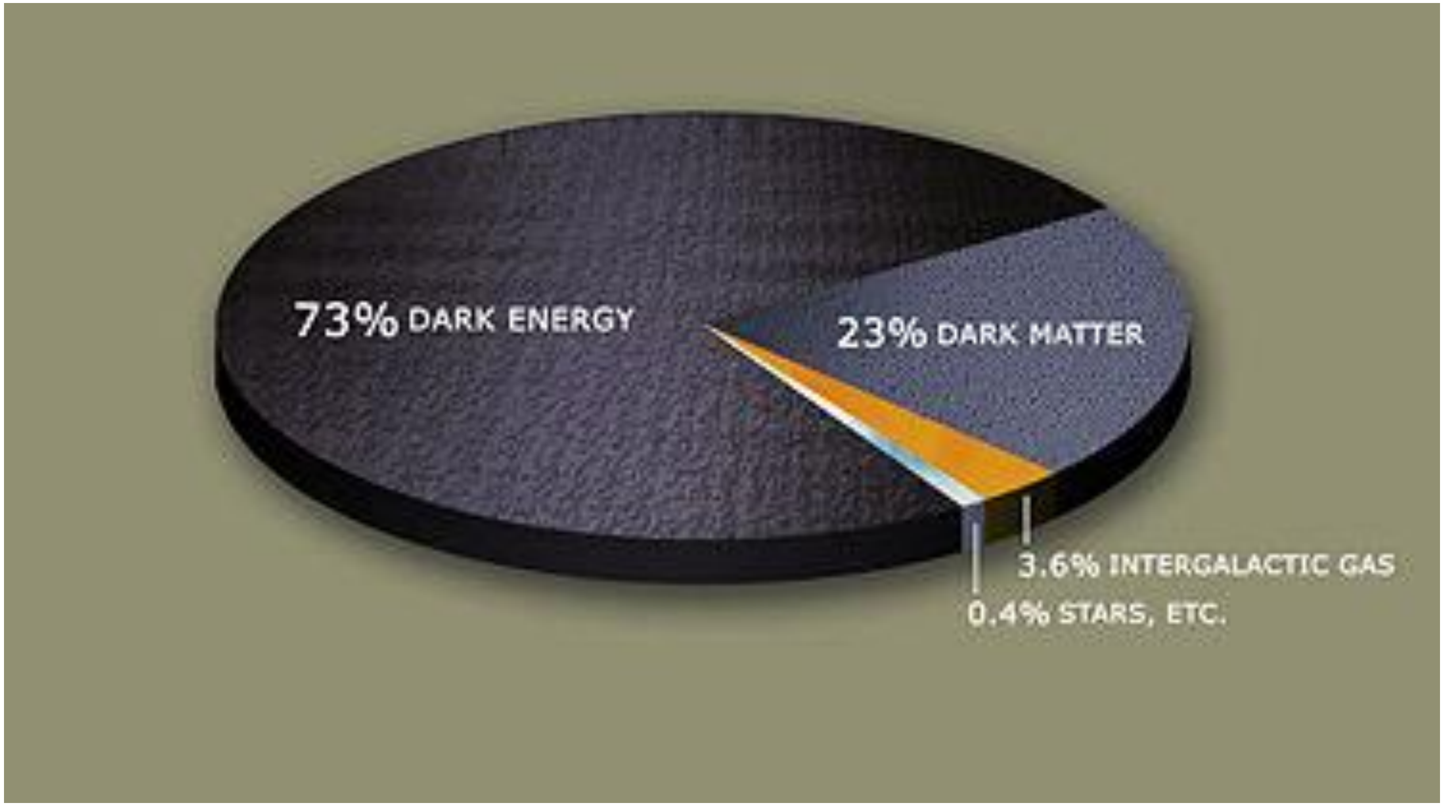
The portion of the universe



The structure

- Standard model particles:

  super-cluster→cluster→Galaxy→star

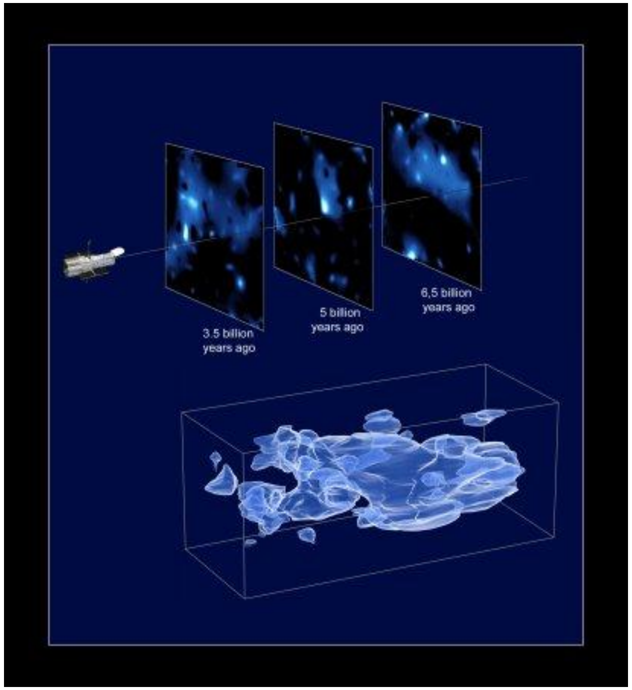
- Dark matter: (neutralino?) R. Massey *et al.*, *Nature* ***445 (2007) 286***

  gravitational seed

  →dark galaxy ?

  →pure dark matter star?

Not the dark star in "D. Spolyar, K. Freese and P. Gondolo, Phys. Rev. Lett. **100, 051101 (2008)**".



Date: 08 Jan 2007
Satellite: Hubble Space Telescope
Depicts: COSMOS dark matter survey

SUSY dark matter

- Neutralino:

  R-parity: stable

  heavy: several 100 GeV

  weak interaction: hard to detect

  Majorana fermion: self-annihilation

condition to create a star

- Pressure : to avoid collapse
- Finite volume
- Can neutralino satisfy these condition?

Fermion: Pauli exclusive force

example : neutron star, quark star

stable : R-parity

Turn out

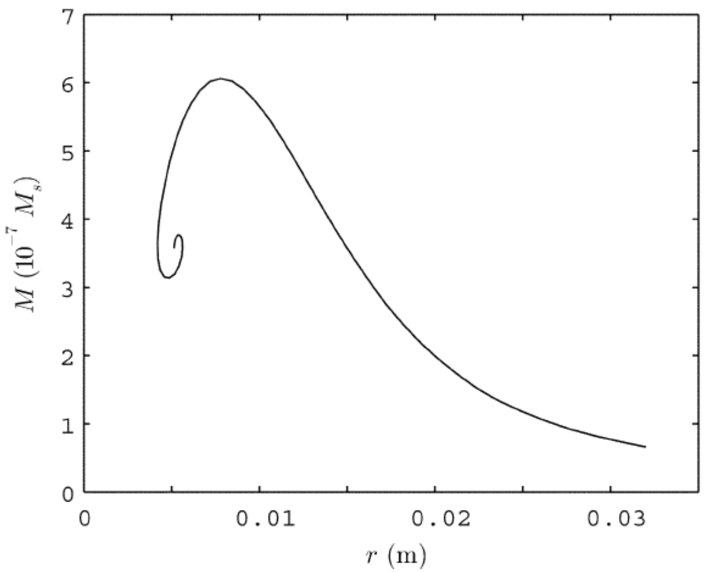


Fig. 2 The mass-radius relation of the neutralino star. M_S denotes the mass of the sun.

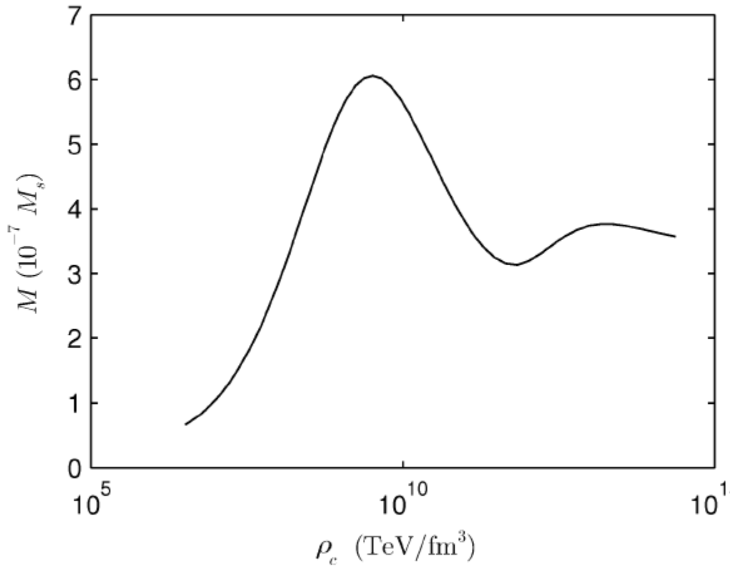


Fig. 3 The mass of the neutralino star as a function of its central mass density. M_S denotes the mass of the sun.

$$\frac{\mathrm{d}p}{\mathrm{d}r} = -\frac{GM\rho}{r^2}\left(1+\frac{p}{\rho}\right)\left(1+\frac{4\pi r^3 p}{M}\right)\left(1-\frac{2GM}{r}\right)^{-1}$$

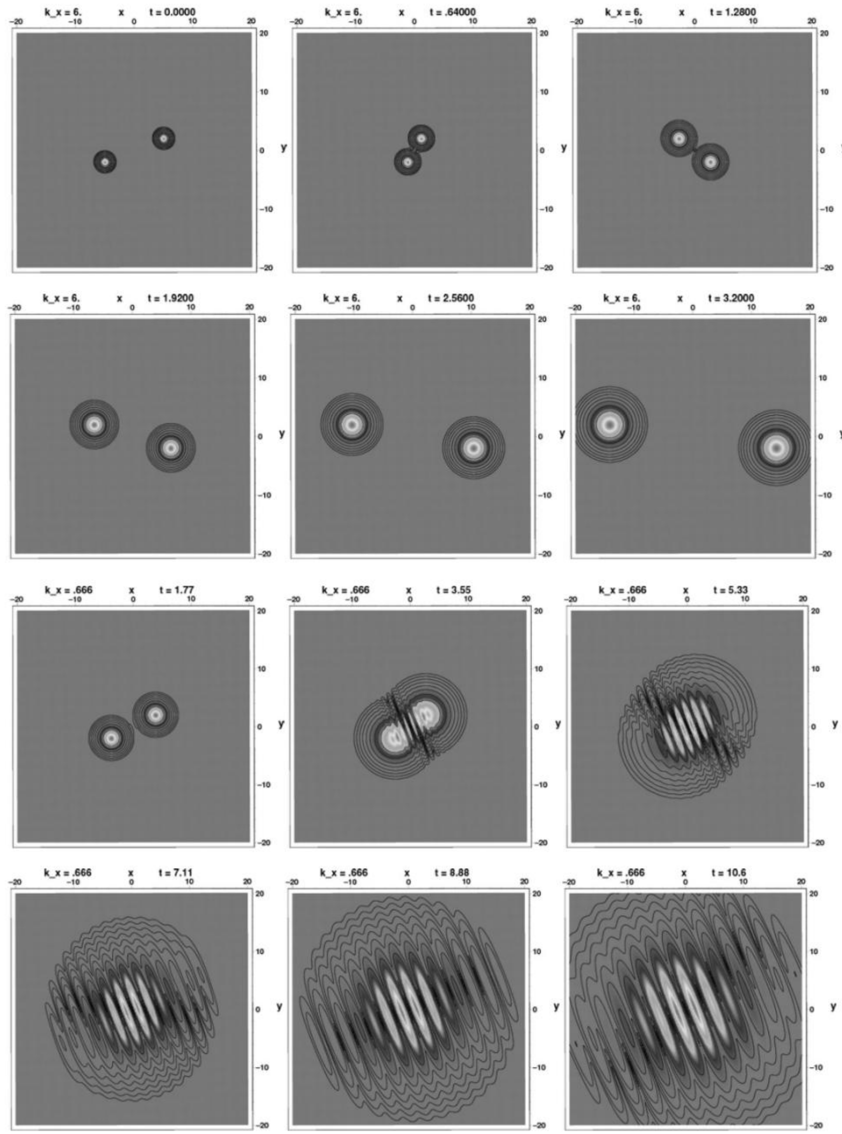
where

$$M(r) = \int_0^r 4\pi r'^2 \rho(r')\,\mathrm{d}r' .$$

$$p = \frac{1}{3\pi^2}\int_0^{k_F} \frac{k^4\,\mathrm{d}k}{\sqrt{k^2+m^{*2}}} - \frac{1}{2}m_H^2 H^2 - \frac{1}{2}m_h^2 h^2 + \frac{1}{2}m_Z^2 Z^2 .$$

Question: If the interaction between neutralinos is weak, how can they exchange energy and become thermal

Entanglement?



D. Pfenniger and V. M. G. Observatory, A&A 456, 45 (2006)

$$\sigma \sim \pi \lambda_{\rm dB}^2$$

The neutralino

$$Z_N^T \begin{pmatrix} M_1 & 0 & \frac{-ev_1}{2c_W} & \frac{ev_2}{2c_W} \\ 0 & M_2 & \frac{ev_1}{2s_W} & \frac{-ev_2}{2s_W} \\ \frac{-ev_1}{2c_W} & \frac{ev_1}{2s_W} & 0 & -\mu \\ \frac{ev_2}{2c_W} & \frac{-ev_2}{2s_W} & -\mu & 0 \end{pmatrix} Z_N$$

$$= diag\left(M_{\chi_1^0}, M_{\chi_2^0}, M_{\chi_3^0}, M_{\chi_4^0}\right)$$

$$\lambda_B = iZ_N^{1i}\kappa_i^0, \qquad \lambda_A^3 = iZ_N^{2i}\kappa_i^0,$$

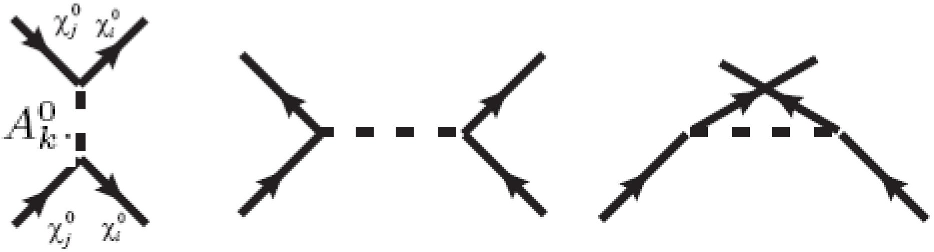
$$\Psi_{H_1}^1 = iZ_N^{3i}\kappa_i^0, \qquad \Psi_{H_2}^2 = iZ_N^{4i}\kappa_i^0, \qquad \chi_i^0 = \begin{pmatrix} \kappa_i^0 \\ \bar{\kappa}_i^0 \end{pmatrix}$$

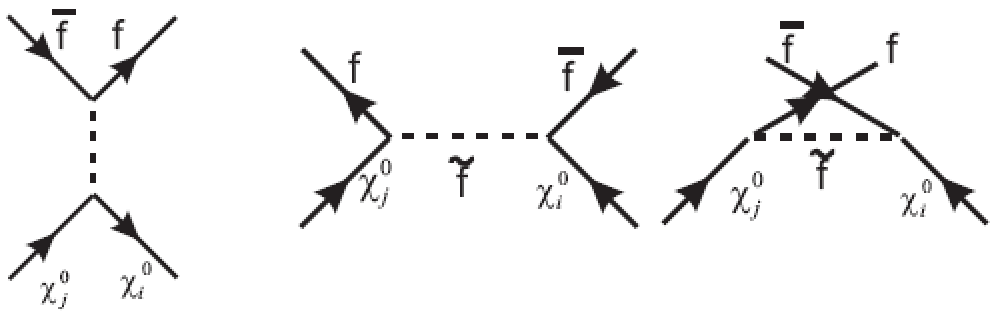
$$M_{\chi_1^0} < M_{\chi_2^0} < M_{\chi_3^0} < M_{\chi_4^0}.$$

Cross section

$$\frac{d\sigma}{d\Omega} = \frac{|P_1|}{16\pi^2 E_A E_B |v_A - v_B| E_{cm}} |M(P_A, P_B \to P_1, P2)|^2$$

Z_μ^0, H_k^0, and A_k^0.





+ ……….

Amplitude for s-channel

Elastic collision

$$M^{(s)}_{el\,Z^0_\mu} \sim (\frac{e}{s_W c_W})^2 \bar{\chi}^0_1 \gamma^\mu \chi^0_1 \frac{1}{s - m_Z^2} \bar{\chi}^0_1 \gamma_\mu \chi^0_1$$

$$M^{(s)}_{el\,H^0_k, A^0_k} \sim (\frac{e}{s_W c_W})^2 \bar{\chi}^0_1 \chi^0_1 \frac{1}{s - m_H^2} \bar{\chi}^0_1 \chi^0_1$$

annihilation

$$M^{(s)}_{ann\,Z^0_\mu} \sim (\frac{e}{s_W c_W})^2 \bar{f} \gamma_\mu f \frac{1}{s - m_Z^2} \bar{\chi}^0_1 \gamma_\mu \chi^0_1$$

$$M^{(s)}_{ann\,H^0_k, A^0_k} \sim (\frac{e}{s_W c_W}) \bar{f}^c f Y_f \frac{1}{s - m_H^2} \bar{\chi}^0_1 \chi^0_1$$

Ignore portion , P_L and P_R

Amplitude for t,u-channel

Elastic collision

$$M^{(t,u)}_{el\,H^0_k,A^0_k} \sim (\frac{e}{s_W c_W})^2 \bar{\chi}^0_1 \chi^0_1 \frac{1}{tu - m_H^2} \bar{\chi}^0_1 \chi^0_1$$

$$M^{(t,u)}_{el\,Z^0_\mu} \sim (\frac{e}{s_W c_W})^2 \bar{\chi}^0_1 \gamma^\mu \chi^0_1 \frac{1}{tu - m_Z^2} \bar{\chi}^0_1 \gamma_\mu \chi^0_1$$

annihilation

$$M^{(t,u)}_{ann} \sim (\frac{e}{s_W c_W})^2 \bar{f}^c \chi^0_1 \frac{1}{tu - m^2_{\tilde{f}}} \bar{f} \chi^0_1$$

conclusion

- Neutralinos follow collisionless Boltzman equation
- Neutralino type of dark matter does not become a thermal star.