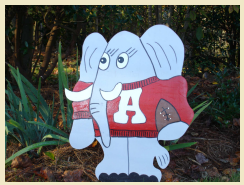


Astrophysical Susy:

The high energy density frontier

L. Clavelli, U of Alabama

(with Peter Biermann of Bonn, Alabama, etc.)

Susy10, Bonn 2010

A transition to exact susy in dense matter might explain several astrophysical puzzles

Some Astrophysical Puzzles

- **Gap in Black Hole Mass Distribution**

  Jenny Greene, ..

- **Energy deficit in Supernovae**

  A. Mezzacappa, ..

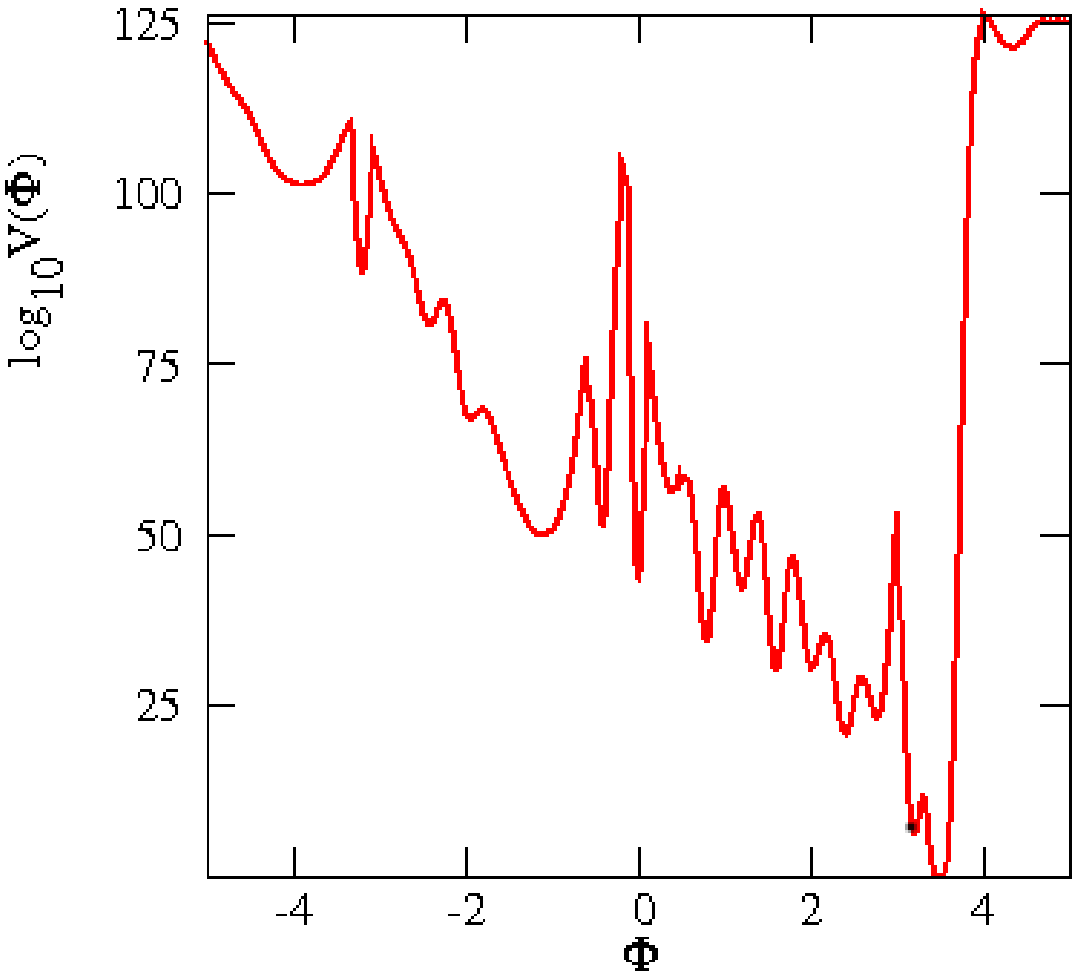
- **Shortage of Cool White Dwarfs**

  D. Winget, ..

- **Shortage of White Dwarf Accretion Disks**

  M. Gilfanov and A. Bogdan

A possible string Landscape



We propose that the ground state of the universe is exactly supersymmetric with zero vacuum energy

N.b.: String theory inspires but gives few unique results

We don't have to assume an AdS ground state

Phase transitions could be accelerated in dense matter

A.S. Gorsky and V.G. Kiselev,
Phys. Lett. B304,214 (1999)

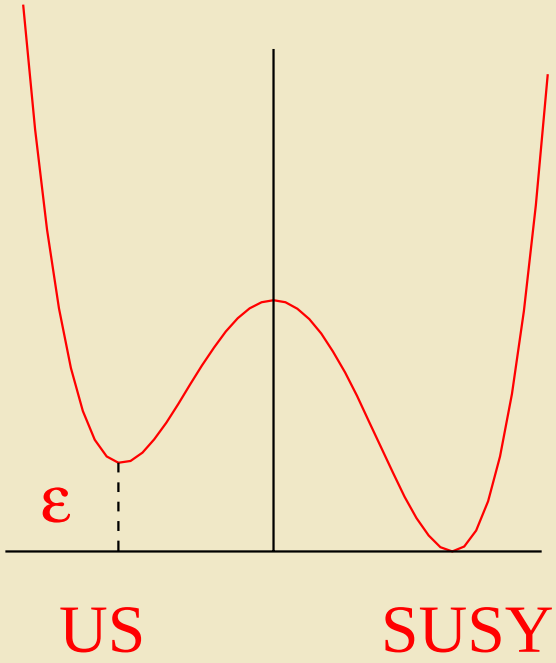
M.B. Voloshin, Phys. Rev. D49, 2014 (1994)

Proven as yet only in lower dimensions

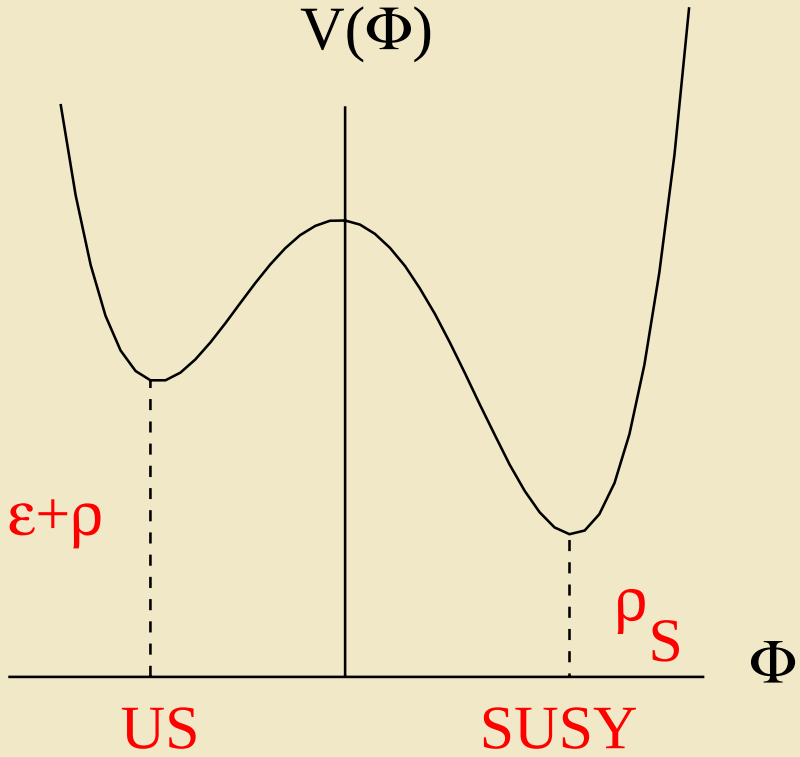
Could susy be nature's way to release the energy stored in the Pauli towers?

Vacuum Decay

Coleman-DeLuccia



dense matter analog



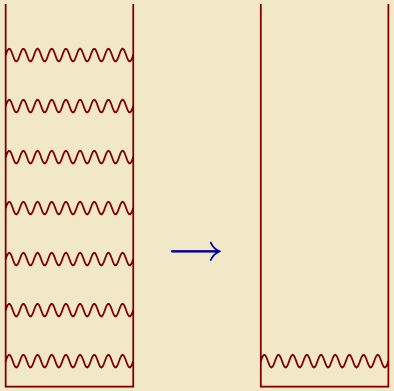
vac energy density $\varepsilon = 3560$ MeV/m^3

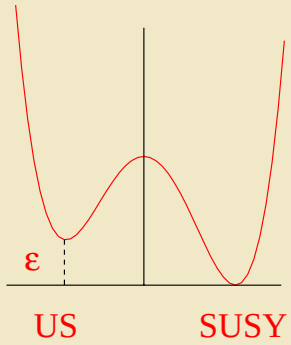
In dense matter $\epsilon \longrightarrow \epsilon + \rho - \rho_s = \epsilon + \Delta\rho$

$$\frac{d^2P}{dtd^3r} = A_C\, e^{-\frac{27\pi^2 S^4}{2\hbar c\epsilon^3}} \longrightarrow A_C\, e^{-\frac{27\pi^2 S^4}{2\hbar c(\epsilon+\Delta\rho c^2)^3}}$$

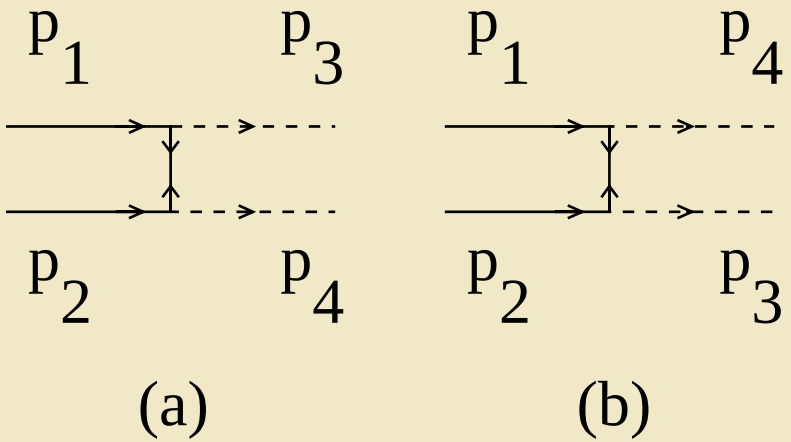
Bose-Fermi degeneracy + pair conversion process

$\longrightarrow$ significant energy release



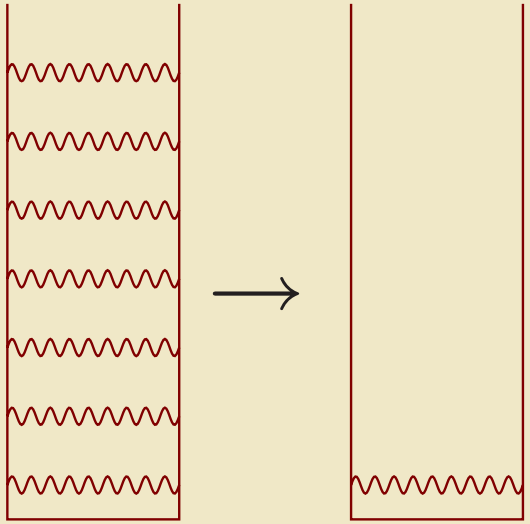


vac energy density $\varepsilon = 3560$ MeV/m^3



$$f + f \rightarrow \tilde{f} + \tilde{f}$$

Energy release in a transition to exact susy



$$\Delta\rho = \rho\frac{\Delta E}{A\,M_n\,c^2} = \frac{1}{2}\left((\frac{2\,N}{A})^{5/3} + (\frac{2\,Z}{A})^{5/3}\right)\frac{3\,(9\pi)^{2/3}}{40}\frac{\hbar\,\rho}{M_n\,c\,R_0} \approx 0.02\rho$$

for comparison, standard hydrogen fusion into Helium: $\Delta\rho = .007\rho$

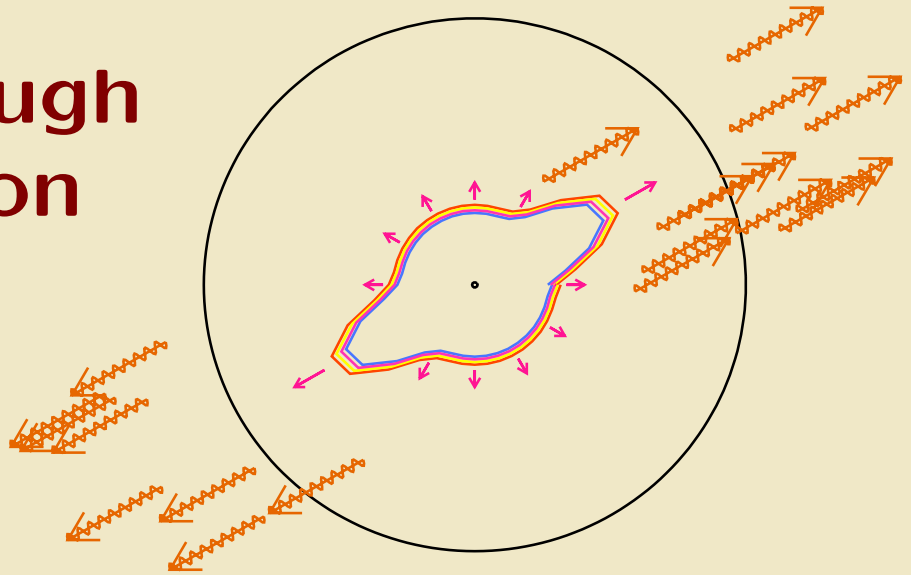
standard triple alpha process: $\Delta\rho = 5.6 \cdot 10^{-4}\,\rho$

bubble of exact susy in dense matter

freely escaping photons below
the Fermi energy (1 MeV)

total energy in Pauli tower $\approx 10^{51}$ ergs

jet structure through
stimulated emission

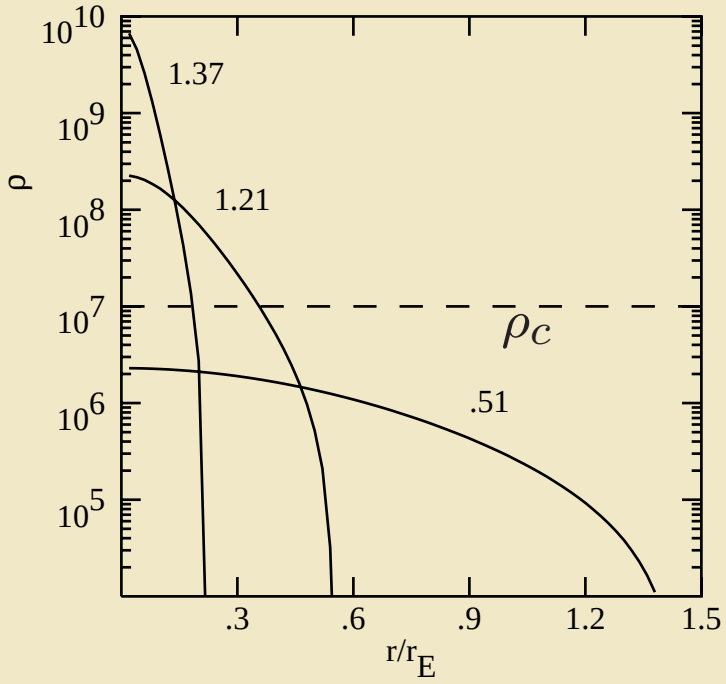


Transition probability in dense matter

$$\frac{dP}{dt} = \frac{1}{\tau_0} \int \frac{d^3r}{V_0} e^{-(\frac{\rho_c}{\rho(r)})^3}$$

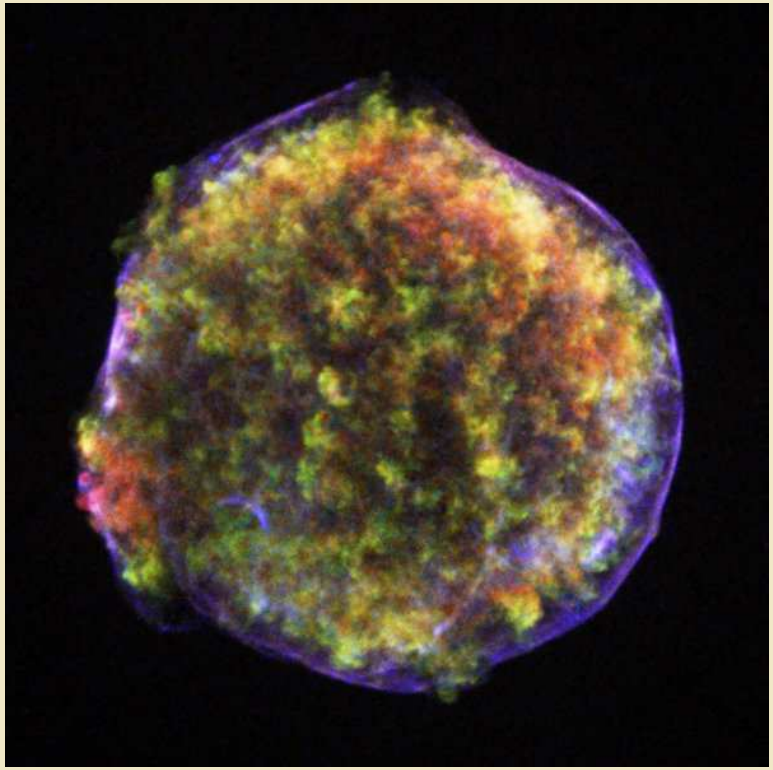
parameters: $\tau_0 V_0$ **and critical density** ρ_c

$$\frac{dP}{dt} = \frac{1}{\tau_0} \frac{V_c}{V_0}$$



Alternative Energy Source for Supernovae?

Are neutrinos the starbreakers?



SN fizzle in std model monte-carlos.

(Mezzacappa, Duan, ...)

Susy could provide the needed boost.

The lifetime of a star against conversion to susy is inversely proportional to its critical volume

(its volume with greater than critical density)

$$\frac{dP}{dt} = \frac{1}{\tau_0} \int \frac{d^3r}{V_0} e^{-(\frac{\rho_c}{\rho(r)})^3} = \frac{1}{\tau_0}\frac{V_c}{V_0}$$

parameters: $\tau_0 V_0$ **and critical density** ρ_c

$V_c \approx M/\rho_c$

The Black Hole Gap

Evidence abounds for black holes of Mass $> 10^5\, M_{solar}$

and for Masses $< 100\, M_{solar}$

but not for intermediate masses.

Schwarzschild radius: $R_S = 2\, G_N\, M/c^2$

$$= 4.64\, 10^{-4}\, R_E\, M/M_\odot$$

Maximum density before becoming black hole:

$$\rho_{max} = \frac{3\, M}{4\, \pi\, {R_S}^3} = \rho_{WD} \left(\frac{10^5\, M_\odot}{M} \right)^2$$

(nominal white dwarf density $\rho_{WD} = \frac{3\, M_\odot}{4\pi\, R_E^3}$ **)**

The Black Hole Gap

Stars of greater than $10^5\ M_\odot$ become black holes before achieving white dwarf density

$$\rho_{max} = \frac{3\,M}{4\,\pi\,{R_S}^3} = \rho_{WD}\left(\frac{10^5\,M_\odot}{M}\right)^2$$

(nominal white dwarf density $\rho_{WD} = \frac{3\,M_\odot}{4\pi\,R_E^3}$)

Dearth of cool white dwarfs?

Data from Sloan Digital Sky Survey

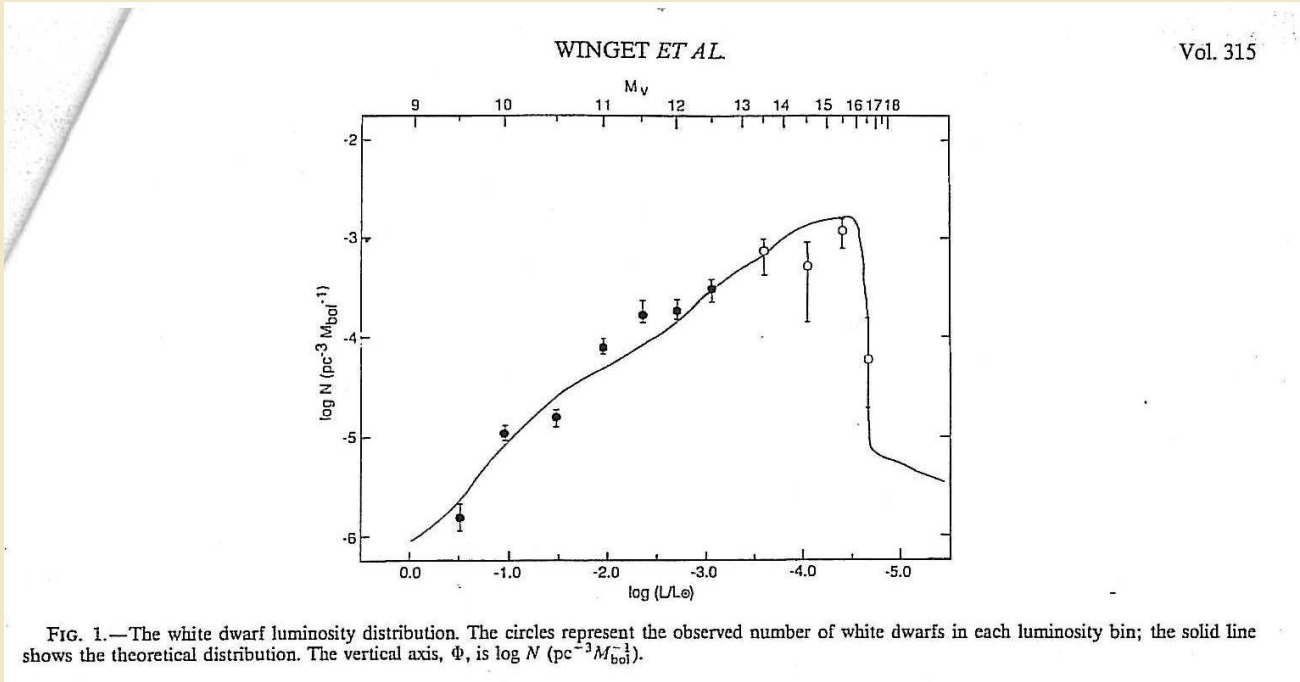
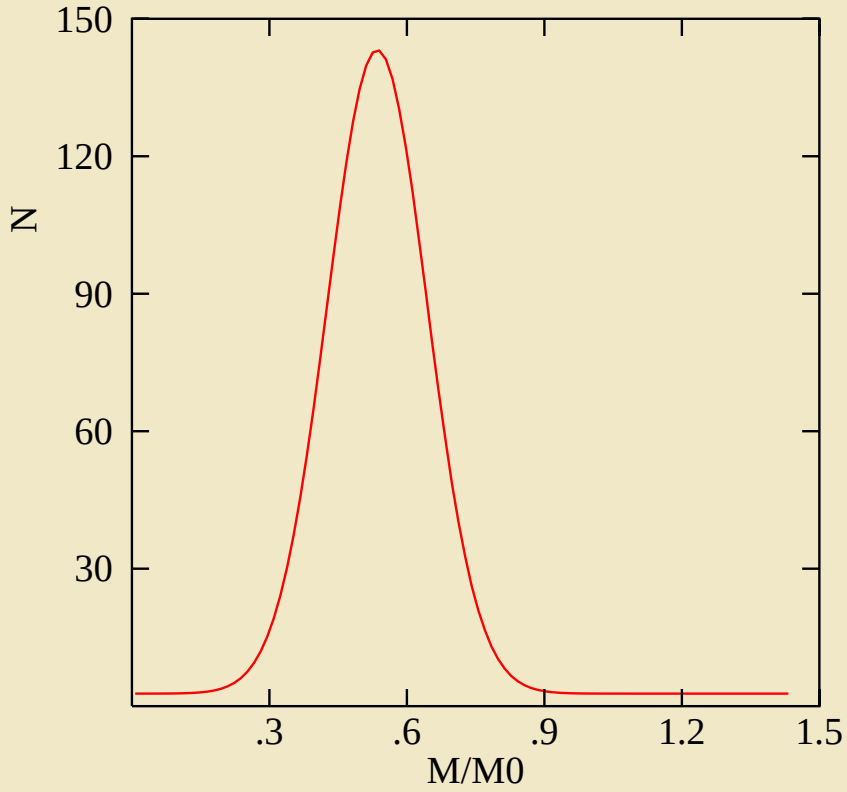


FIG. 1.—The white dwarf luminosity distribution. The circles represent the observed number of white dwarfs in each luminosity bin; the solid line shows the theoretical distribution. The vertical axis, Φ, is log N ($pc^{-3}M_{bol}^{-1}$).

The unexpected shortage of cool white dwarfs has been interpreted as a galactic disk age of only 8 Gyr.

rough fit to mass distribution of white dwarfs from SDSS



Conclusions:

Assume: transition to exact susy enhanced at high density

Results:

- **threshold in black hole spectrum at $\approx 10^5\, M_\odot$**
- **extra energy for supernovae explosions**
- **dearth of cold white dwarfs**
- **collapse of isolated white dwarfs**

Predictions:

- **low mass black holes below Chandrasekhar mass $1.4\, M_\odot$**
- **our world should be a broken susy universe (LHC)**
- **eventual vacuum decay of entire universe to exact susy**