String Landscape and Supernovae Ia

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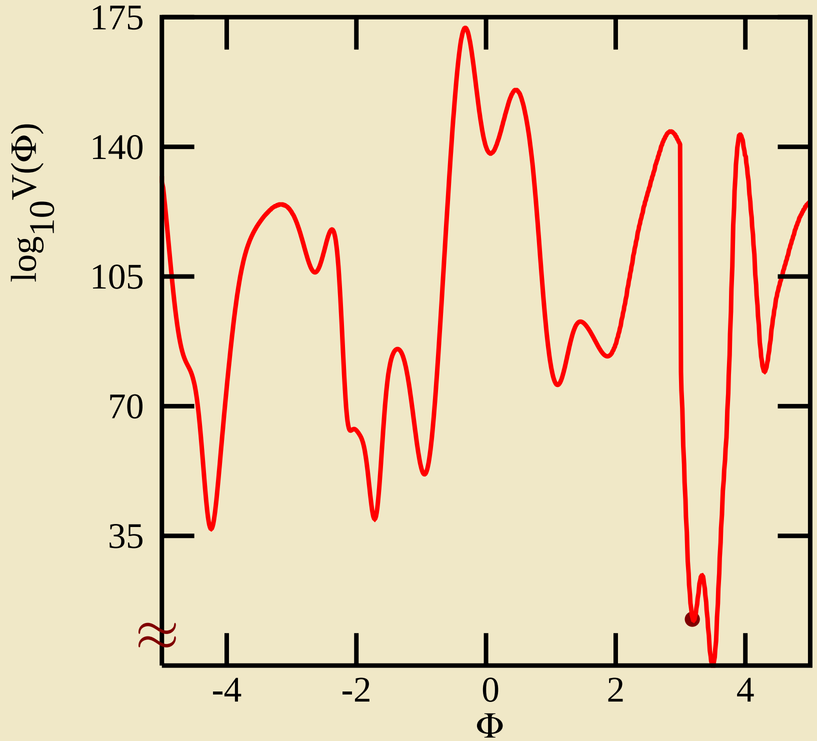
(with Peter Biermann, UA, Bonn, Karlsruhe ...)

Susy11, Fermilab, August 2011

Should we take the string landscape seriously?

First Theory House at Fermilab, 1969

A Bicuspid Landscape?

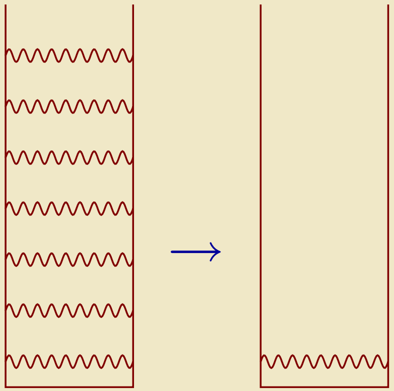


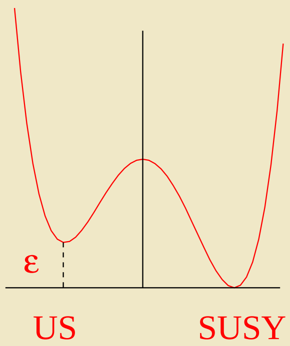
time constant for volume expansion of the universe:

$$\tau = \frac{1}{\sqrt{24\pi G_N \epsilon}} = 5.6 \cdot 10^9 yr \left(\frac{2.3 \cdot 10^{-3} eV}{\epsilon} \right)^{1/2}$$

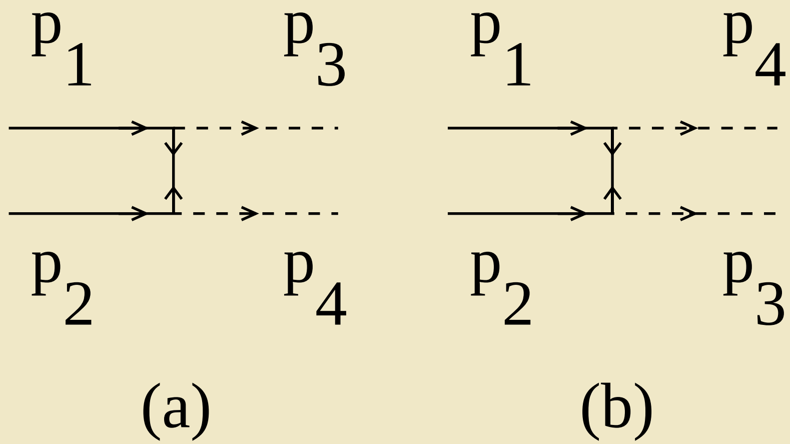
a supersymmetric universe

a world of greatly weakened Pauli Principle





vac energy density ε = 3560 MeV/m^3



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

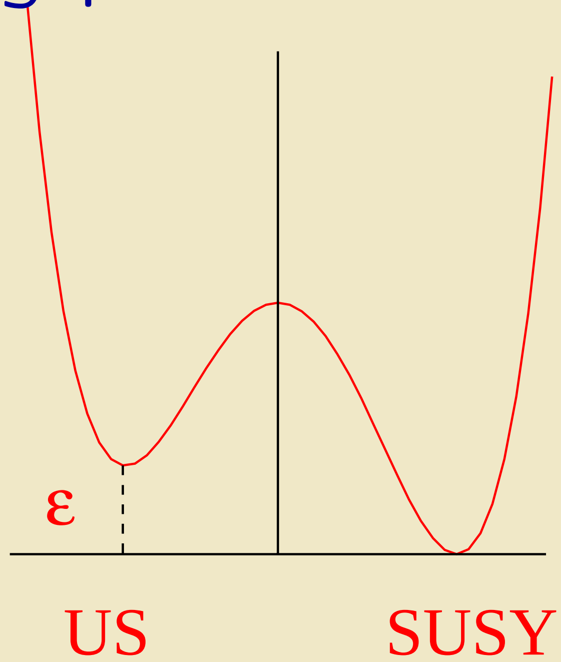
Phase transitions could be accelerated in dense matter

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

Proven as yet only in lower dimensions

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

Starting point: Coleman-DeLuccia formula (1980)



$$\frac{d^2P}{dtd^3r} = A_C e^{-B(vac)}$$

$$B(vac) = \frac{27\pi^2 S^4}{2\,\hbar\,c\,\epsilon^3}$$

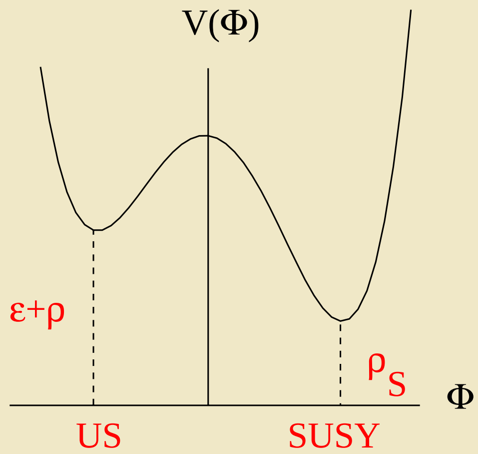
$$B(matter) = \frac{27\pi^2 S^4}{2\,\hbar\,c\,(\epsilon+\Delta\rho)^3}$$

vac energy density ε = 3560 MeV/m^3

Fermi Gas Model: $\Delta\rho = 0.02\rho$

$$\text{B(matter)} = (\frac{\rho_c}{\rho})^3$$

$$A_C = \frac{1}{\tau_0 V_0}$$

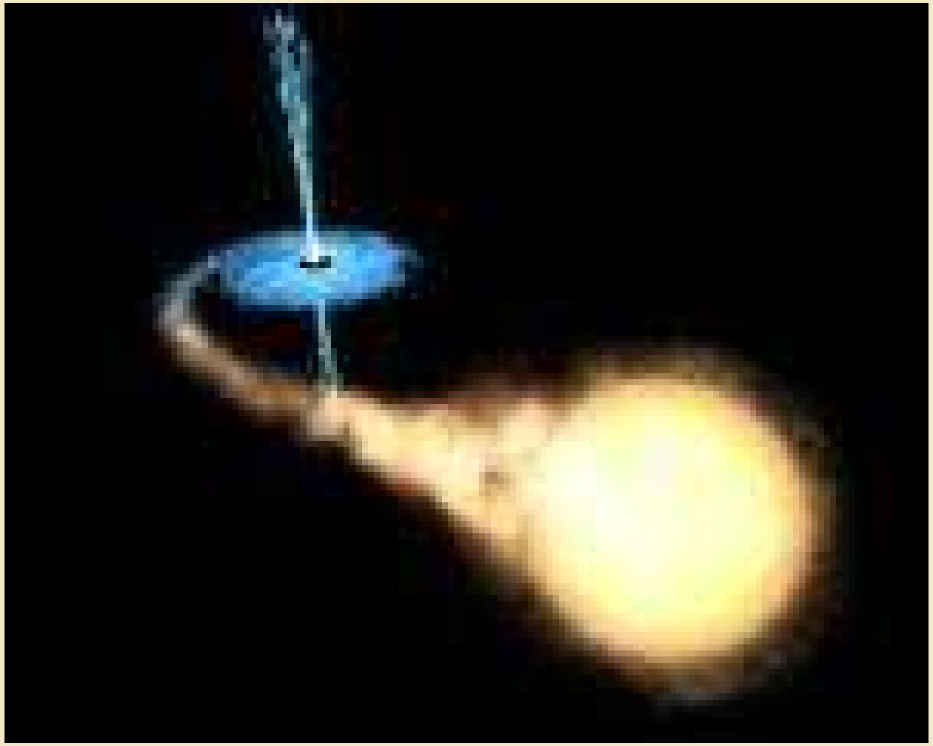


Primary features of SN Ia:

1. No hydrogen in emission
2. homogeneity: standardizable candles
3. light curve dominated by Ni^{56} production and decay
4. Rate: About one per century per galaxy
   (more in star-burst galaxies => short time scale for SN Ia production)
5. but also observed in old galaxies => range of time scales

main sequence star accreting onto a white dwarf

(single degenerate scenario)



astronomers have spent thousands of man-years explaining how such accretion disks could cause Supernovae Ia.

But they don't!

Gilfanov and Bogdan (Nature 2010):

95% of SN Ia don't occur like this.

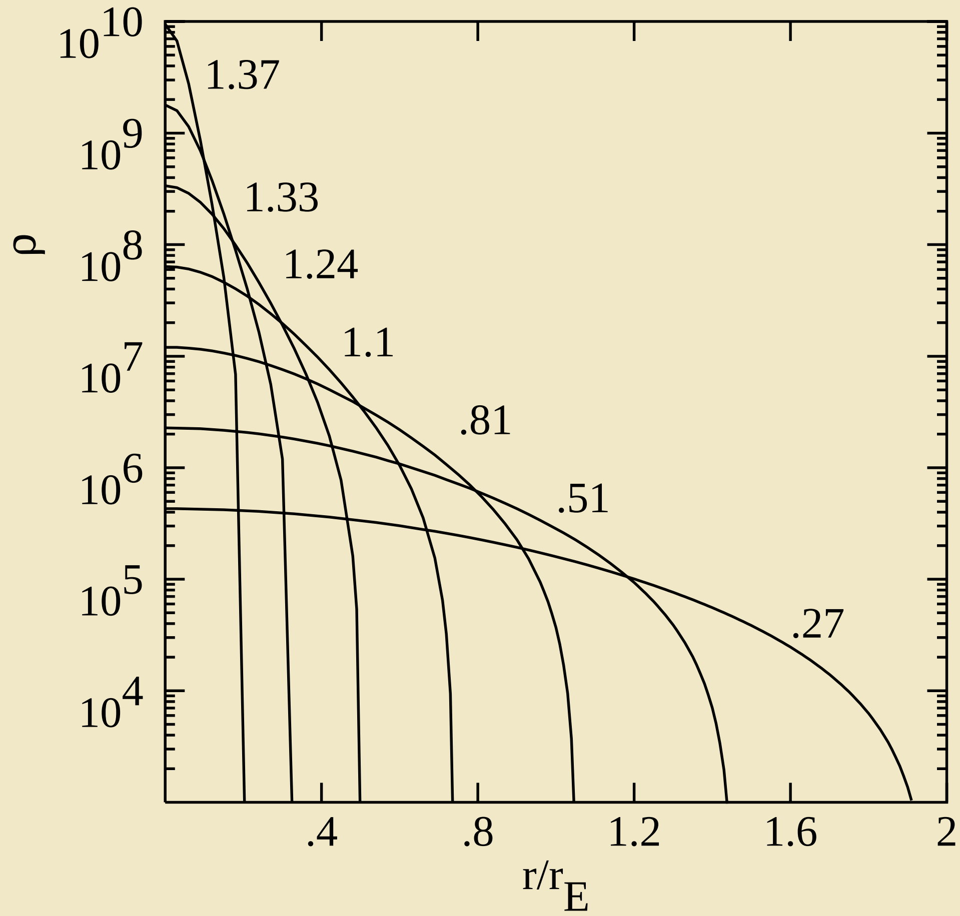
(similar conclusion: Bianco et al. ArXiv:1106.4008

The Double Degenerate Scenario (two white dwarfs accreting from one to the other)

2008 review by Hillebrandt and Niemeyer:

"Besides the lack of convincing direct observational evidence for sufficiently many appropriate binary systems, the homogeneity of 'typical' SNe Ia may be an argument against this class of progenitors. It is not easy to see how the merging of two white dwarfs of (likely) different mass, composition, and angular momentum with different impact parameters, etc, will always lead to the same burning conditions and, therefore, the production of a nearly equal amount of ^{56}Ni."

some of Chandra's white dwarfs



density distribution in seven typical white dwarfs

(masses given relative to solar mass)

Basic Assumption:

In any object containing heavy nuclei (above He)

The probability per unit time per unit volume

to convert to exact susy is:

$$\frac{d^2P}{dtd^3r} = \frac{1}{\tau_0 V_0} e^{-\left(\frac{\rho_c}{\rho}\right)^3}$$

$$-\frac{1}{N}\frac{dN}{dt} = \frac{1}{\tau} = \frac{dP}{dt} = \frac{V_c}{\tau_0 V_0}$$

$$V_c \equiv \int d^3 r e^{-\left(\frac{\rho_c}{\rho}\right)^3}$$

Best fit values:

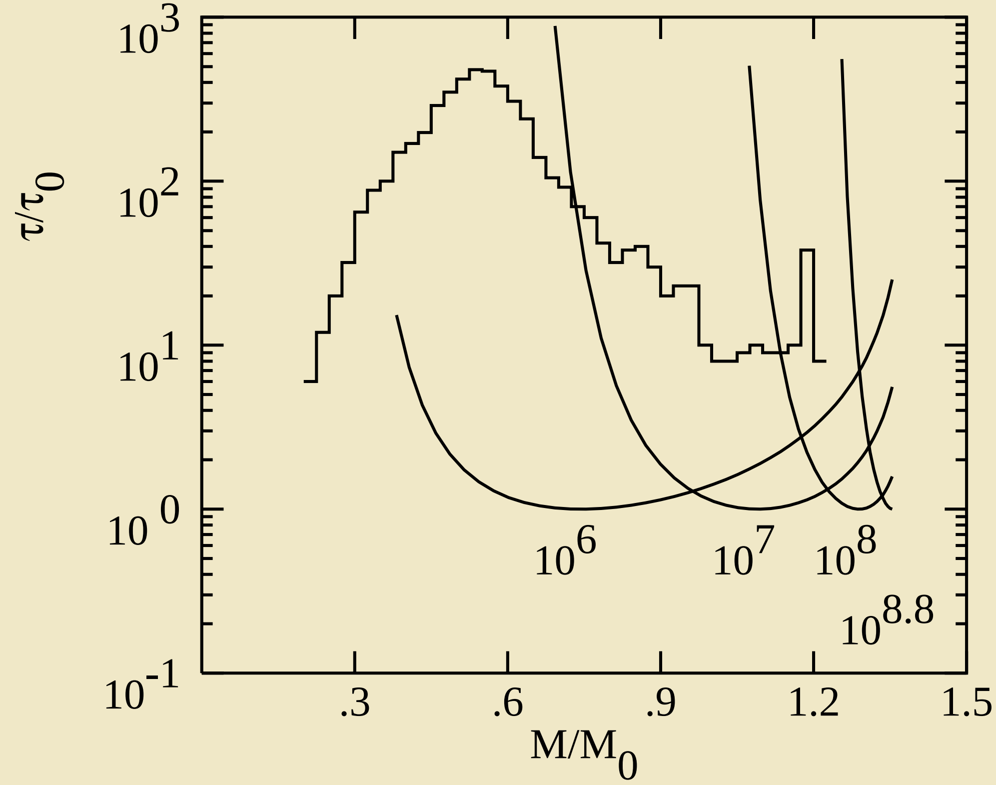
$\rho_c \approx 10^7$ g/cc

$\tau_0 \approx 0.5 \cdot 10^9$ yr

For preferred value of ρ_c choose V_0 to be the

maximum V_c of naturally occuring objects.

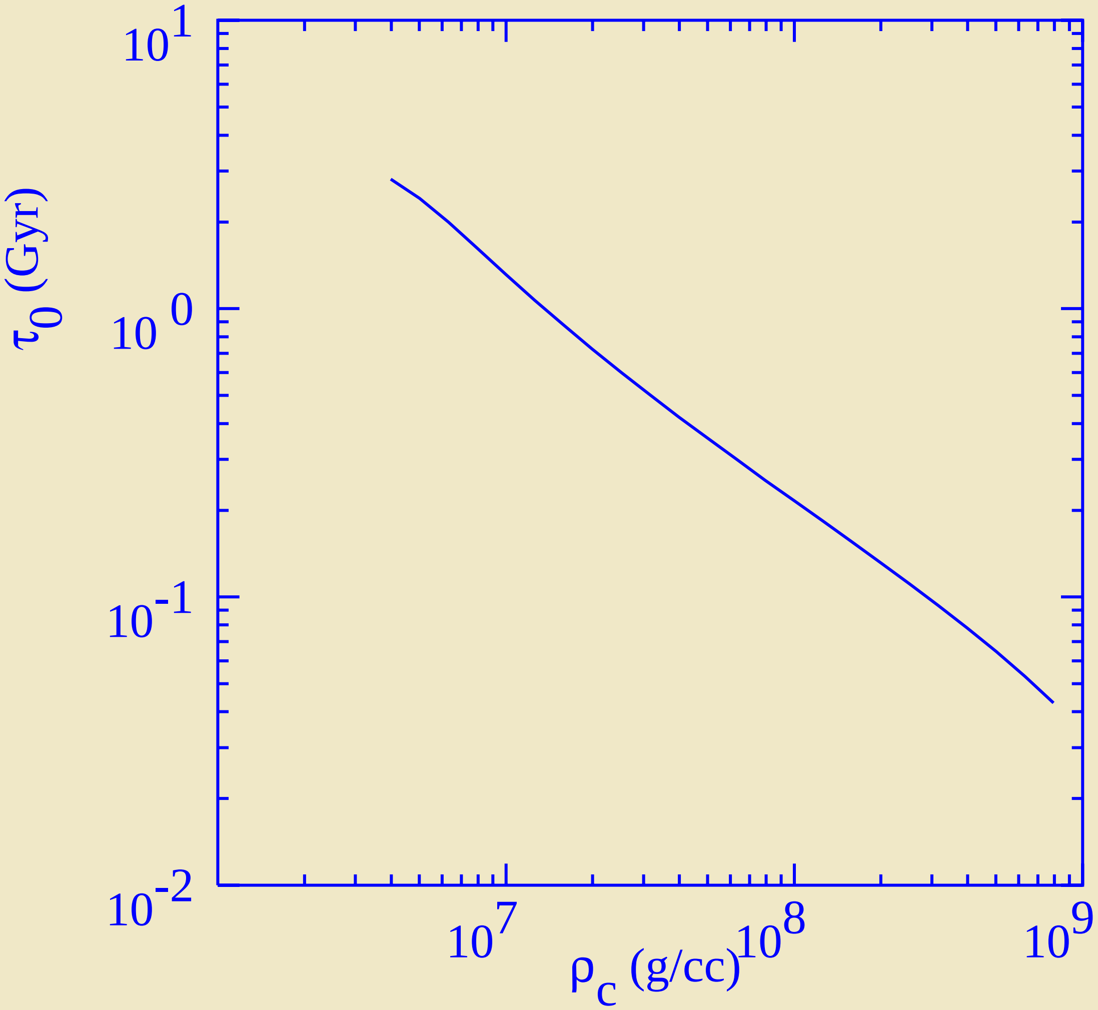
Then τ_0 is the minimum lifetime.



$$\frac{dN_{WD}}{dt} = -\frac{1}{\tau}$$

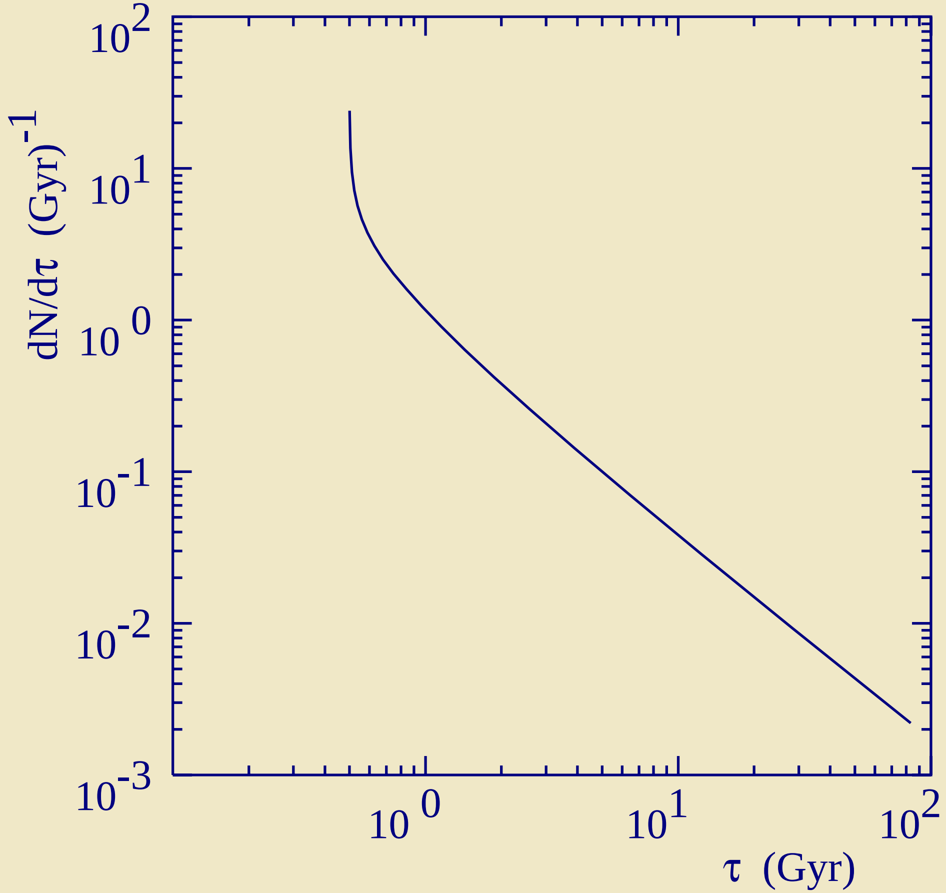
The τ/τ_0 as a function of mass for critical densities of 10^6, 10^7, 10^8, and $6.3 \cdot 10^8$ g/cc.

For appropriate choice of ρ_c, the narrowness of the SN Ia distribution is naturally explained.



Supernova Ia rate: $\frac{dN_{SNIa}}{dt} = N_{WD}\frac{G(\rho_c)}{\tau_0}$

$$G(\rho_c) = \int dM \frac{1}{N_{WD}} \frac{dN_{WD}}{dM} \frac{1}{V_0} \int d^3x e^{-(\rho_c/\rho)^3}$$



Distribution of white dwarf lifetimes

relative to minimum lifetime, $\tau_0 \approx 5 \cdot 10^8$yr

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 $\rho_{WD} = \frac{3\, M_\odot}{4\pi\, R_E^3}$ **)**

Results of two parameter model:

- threshold in black hole spectrum at $\approx 10^5\ M_\odot$
- extra energy for supernovae explosions
- collapse of isolated white dwarfs
- narrow distribution of progenitor masses
- short WD lifetime at optimum mass
- SN rate correctly fit

Predictions:

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

  on time scale $\tau \approx = \frac{1}{\sqrt{24\pi G_N \epsilon_i}} = 5.6 \cdot 10^9 \mathrm{yr}$