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Extrapolation of Cosmological Standard Model in the Past and Cosmogenesis

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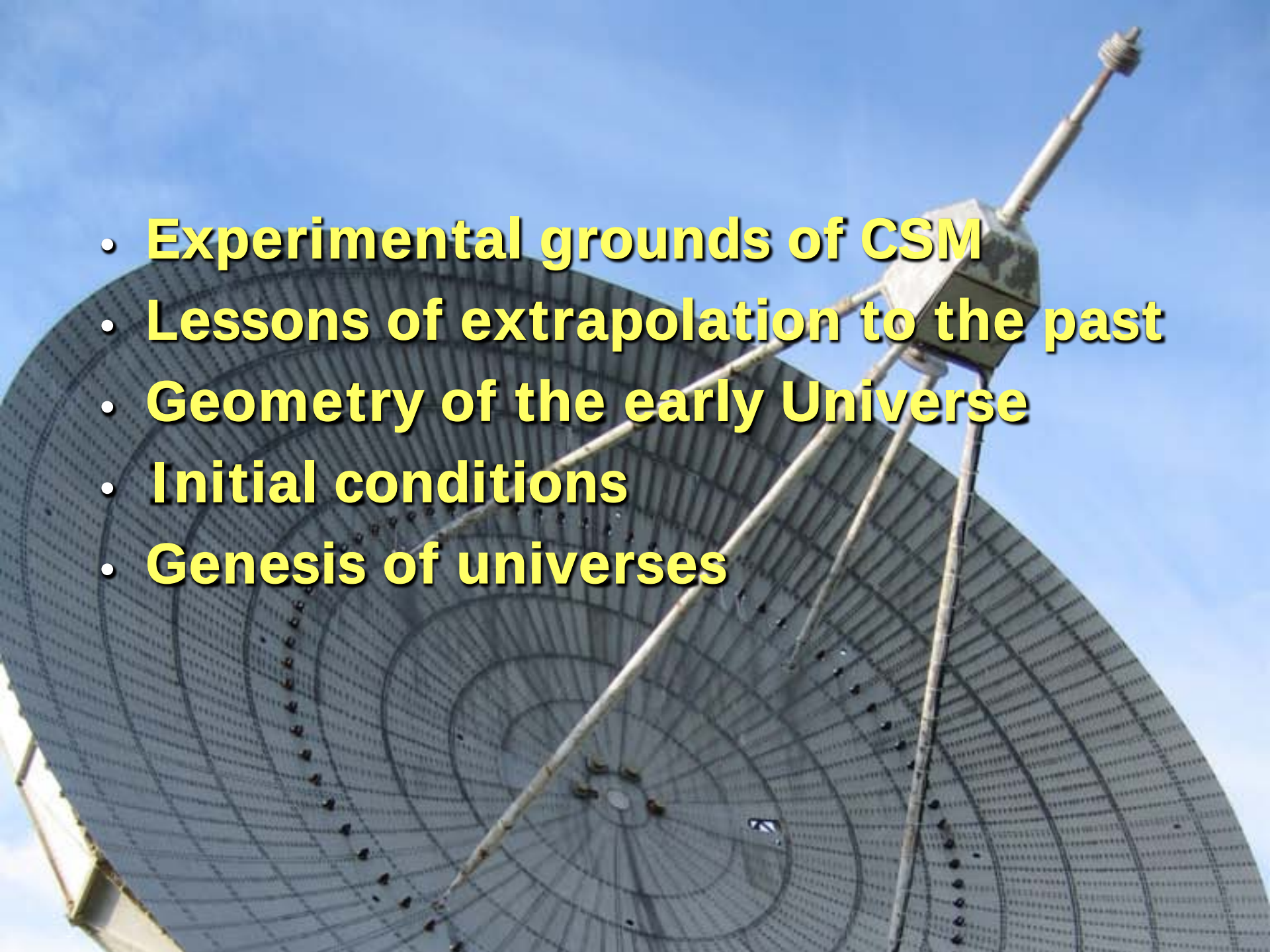
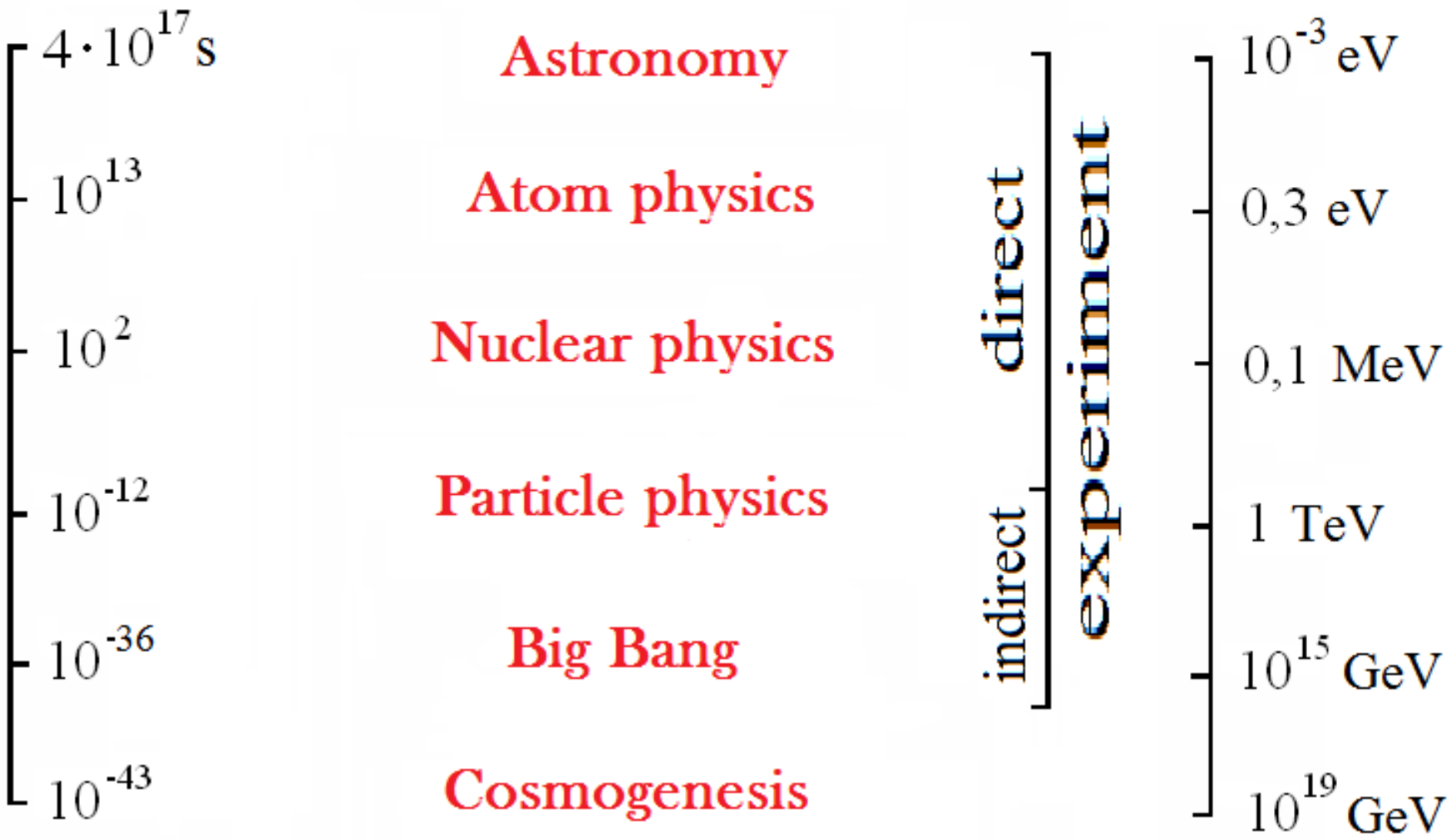
Standard model (GR)
Clustered matter – DM (25%)
Unclustered matter – DE (70%)


• Experimental grounds of CSM
• Lessons of extrapolation to the past
• Geometry of the early Universe
• Initial conditions
• Genesis of universes

Experimental grounds of CSM



question: **where is DM ?**

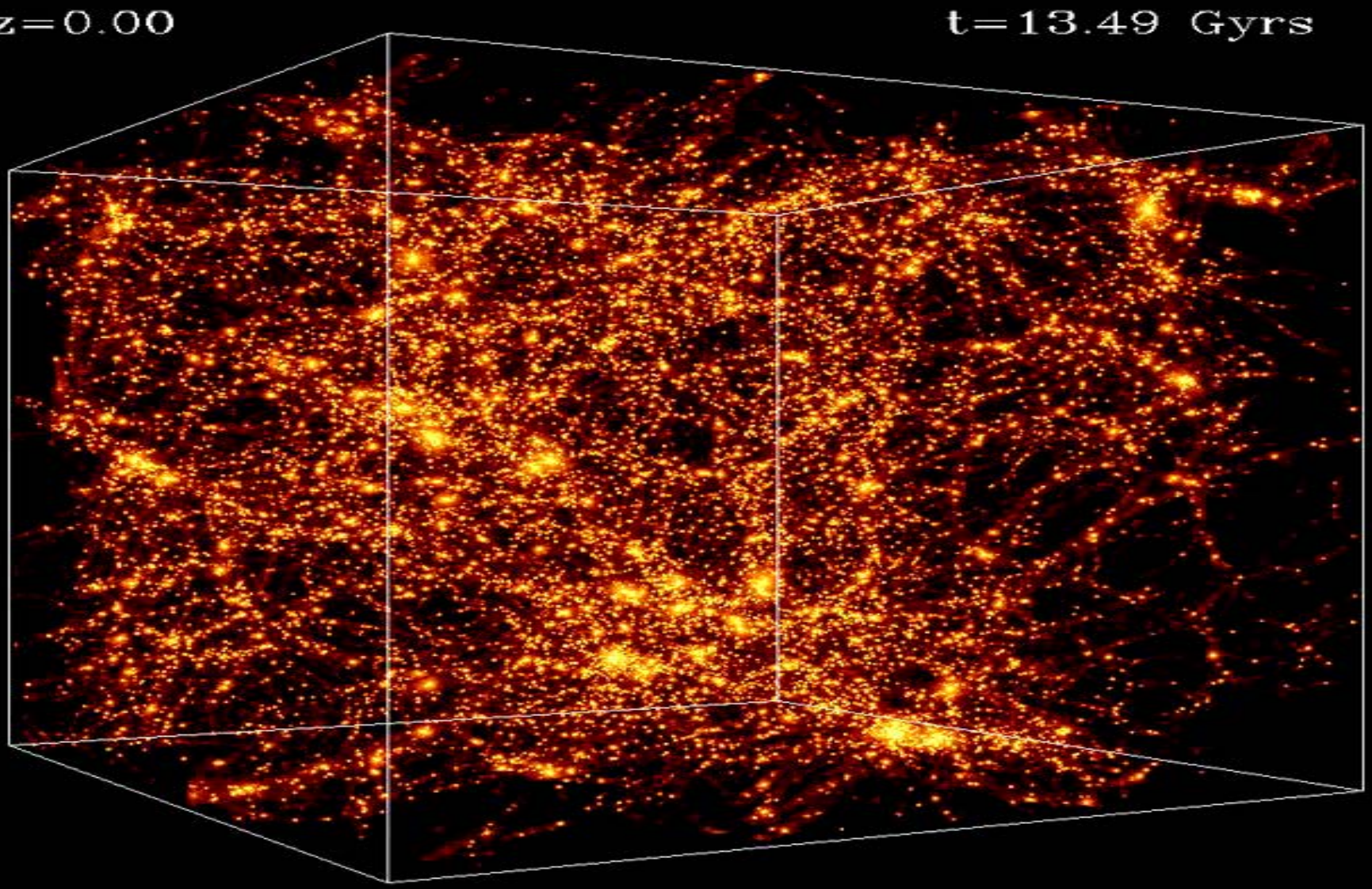
answer: **non-baryonic DM is in gravitationally bound systems**

weakly interacting particles
do not dissipate as baryons

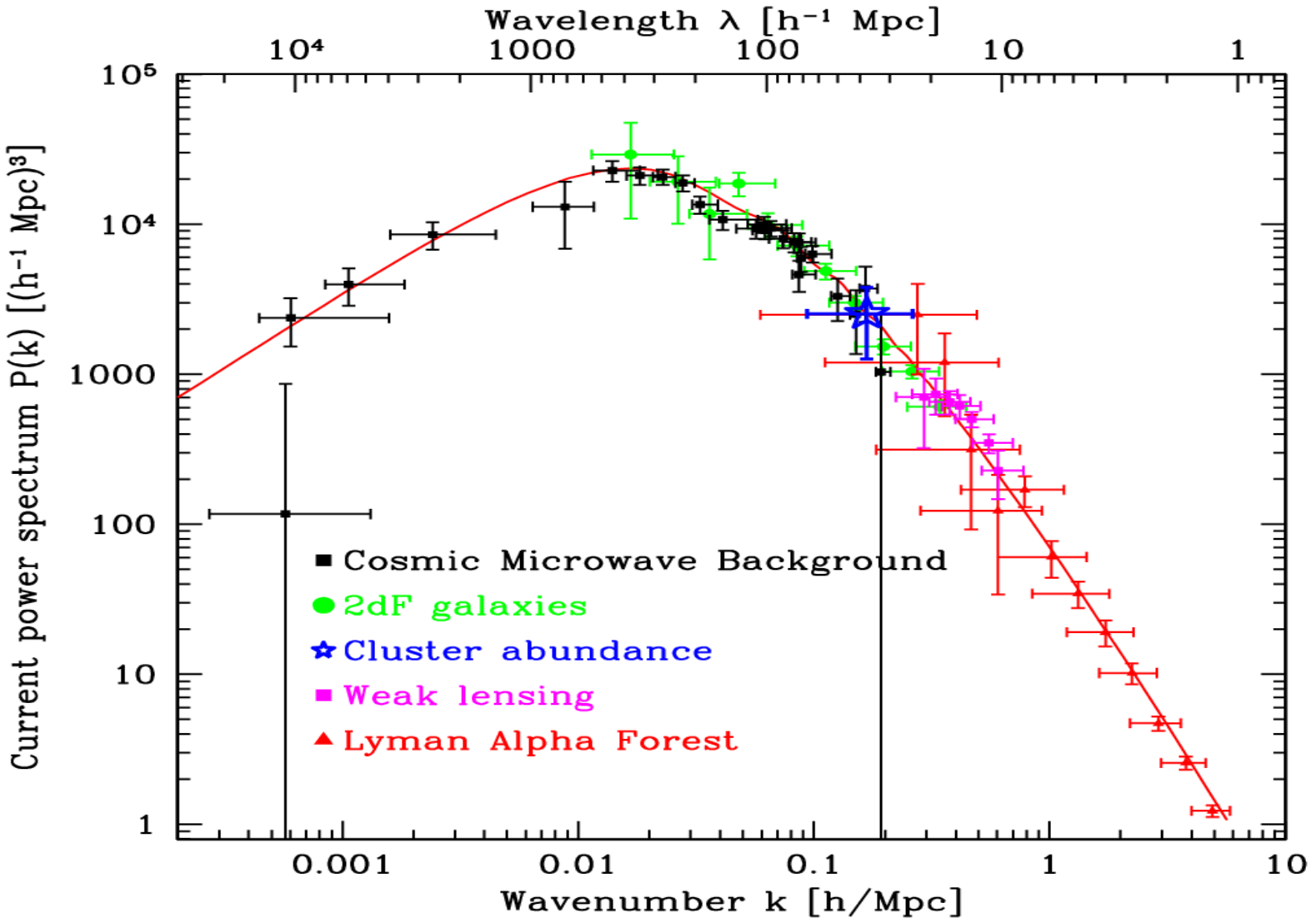
Baryons cool down radiationally and reside in centers of dark matter halos coming to rotational equilibrium

DM remains assembled around the visible matter at the scale ~ 200 kpc

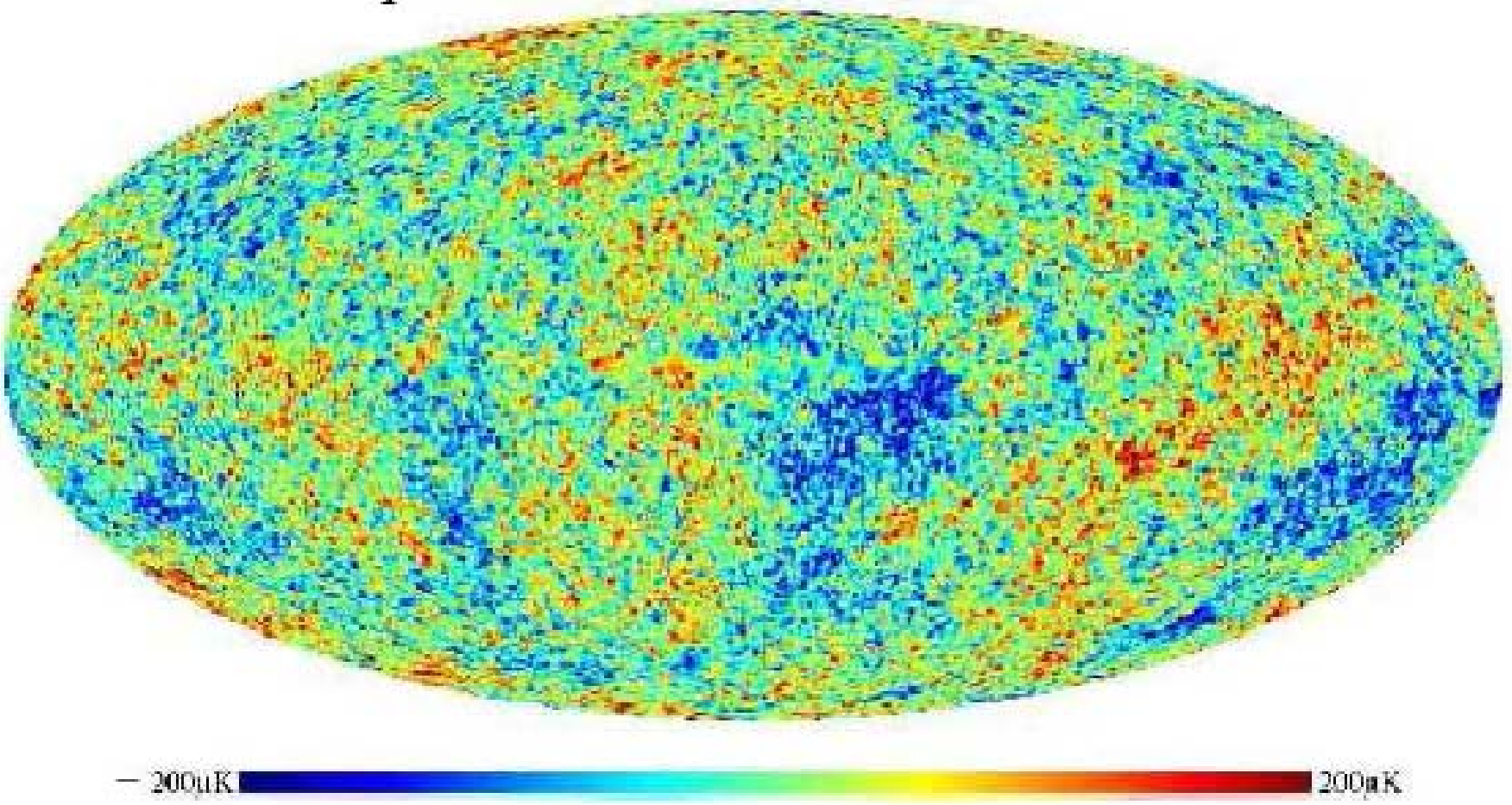
Simulations confirm the result



Cosmological density perturbations



$$T = 2.725^{\circ}K, \quad \frac{\delta T}{T} \sim 10^{-5}$$



WMAP

we observe structure in its evolution

It is enough to determine

separately initial conditions

geomerty of the early Universe

and development conditions

the Cosmological Model

Geometry of the early Universe

(small parameter ~ 10^{-5})

- **Zeroth order** **Hubble diagram** $a(t)$

- **First order** **structure**

  S-mode (density perturbations) $S(k)$

  T-mode (gravitational waves) $T(k)$

  V-mode (vortex perturbations) $V(k)$

Cosmological model is deterministic

Zeroth order

$$\frac{H}{H_0} = 10^{61}\frac{H}{M_P} = \left(\frac{10^{-4}}{a^4} + \frac{0.3}{a^3} + 0.7\right)^{1/2} \Rightarrow \frac{10^{-2}}{a^2}$$

$$\gamma \equiv -\frac{\dot{H}}{H^2} = \frac{2\times 10^{-4} + 0.4}{10^{-4} + 0.3a + 0.7a^4} \subset (2,\ 0.4)$$

$$H_0^{-1} = 14\,Gyr = 10^{33}\,eV^{-1}$$

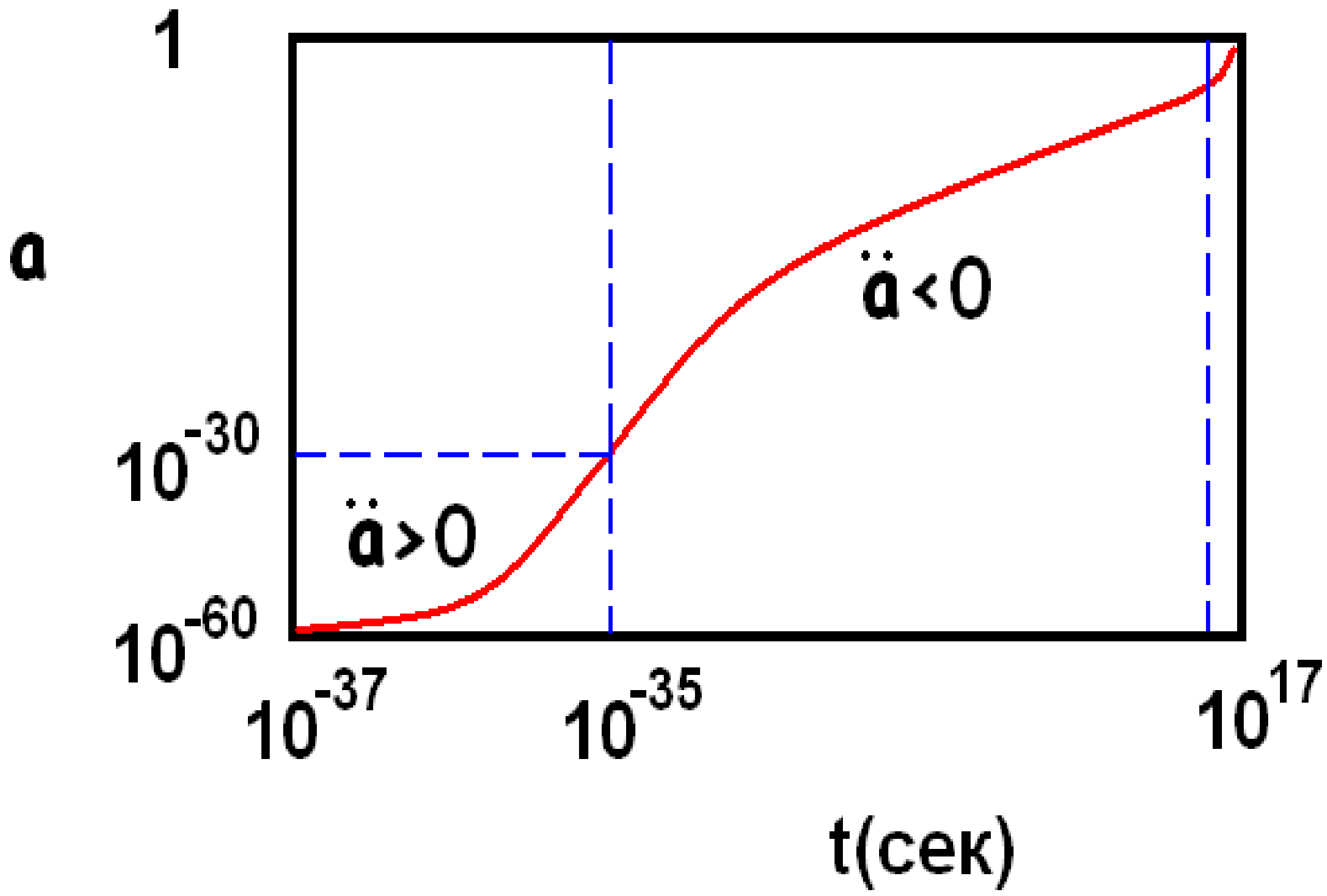
$$M_P = 10^{19}\,GeV = 10^{33}\,cm^{-1}$$

lesson 1: the Universe is large

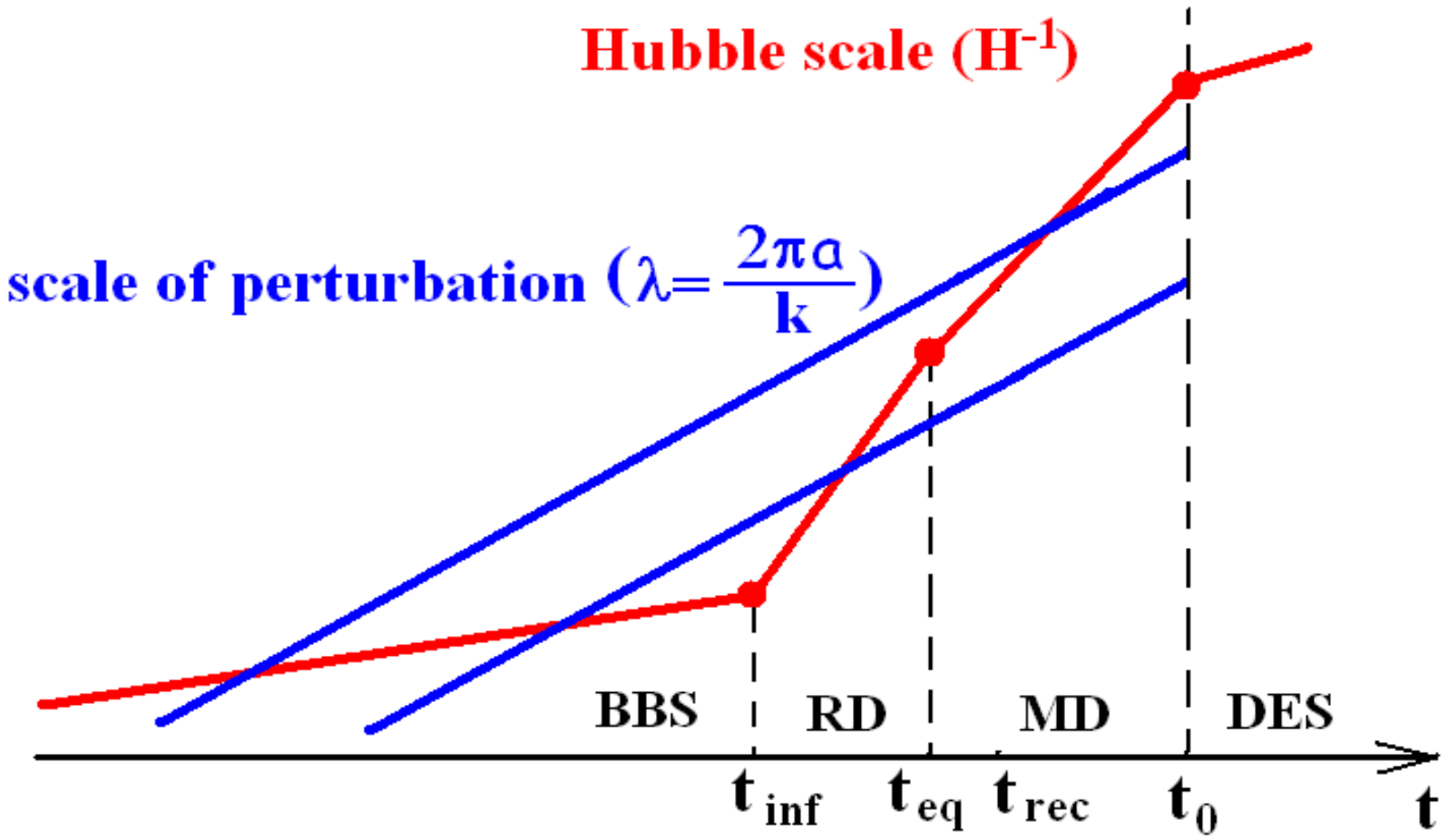
Since the very beginning ($\gamma > 1$) the physical size of the Universe exceeded Planck scale 10^{30} times

This big factor can be explained by existence of preceding short stage of inflation ($\gamma < 1$)

Evolution of the scale factor



lesson 2: non-causality



lesson 3: Gaussian perturbations

First order geometry

S → seeds for DM structure
(galaxies, clusters, voids..)

S+T+V → seeds for CMB structure
(anisotropy and polarization)

T/S < 0.1

Origin of cosmological perturbations

quantum gravitational creation of massless degrees of freedom under the action of non-stationary extensive gravity, from vacuum fluctuations

- **Creation of matter** (Grib, Starobinsky...1970s)
- **Generation of T-mode** (Grishchuk 1974)
- **Generation of S-mode** (V N L 1980)

The problem of generation of S and T perturbation modes in Friedmann model is reduced to quantum-mechanical problem of elementary oscillators ($\omega=\beta k$) in Minkowsky space-time in the external field $\alpha(\eta)$

$$S_k = \int L_k d\eta, \qquad L_k = \frac{\alpha^2}{2k^3}\left(q'^2 - \omega^2 q^2\right)$$

q_T - transverse-traceless component of gravitational field

$$\alpha^2 = a^2 / 8\pi G \ , \qquad \beta = 1$$

q_S - gauge-invariant combination of longitudinal gravitational and velocity potentials

$$\alpha^2 = a^2 \gamma / 4\pi G \beta^2 , \quad \beta = c_s / c$$

Evolution of elementary oscillators

$$\bar{q} = \frac{\alpha}{k} q\,, \quad U = \frac{\alpha''}{\alpha}, \quad \omega = \beta k, \qquad f \equiv U/\omega^2$$

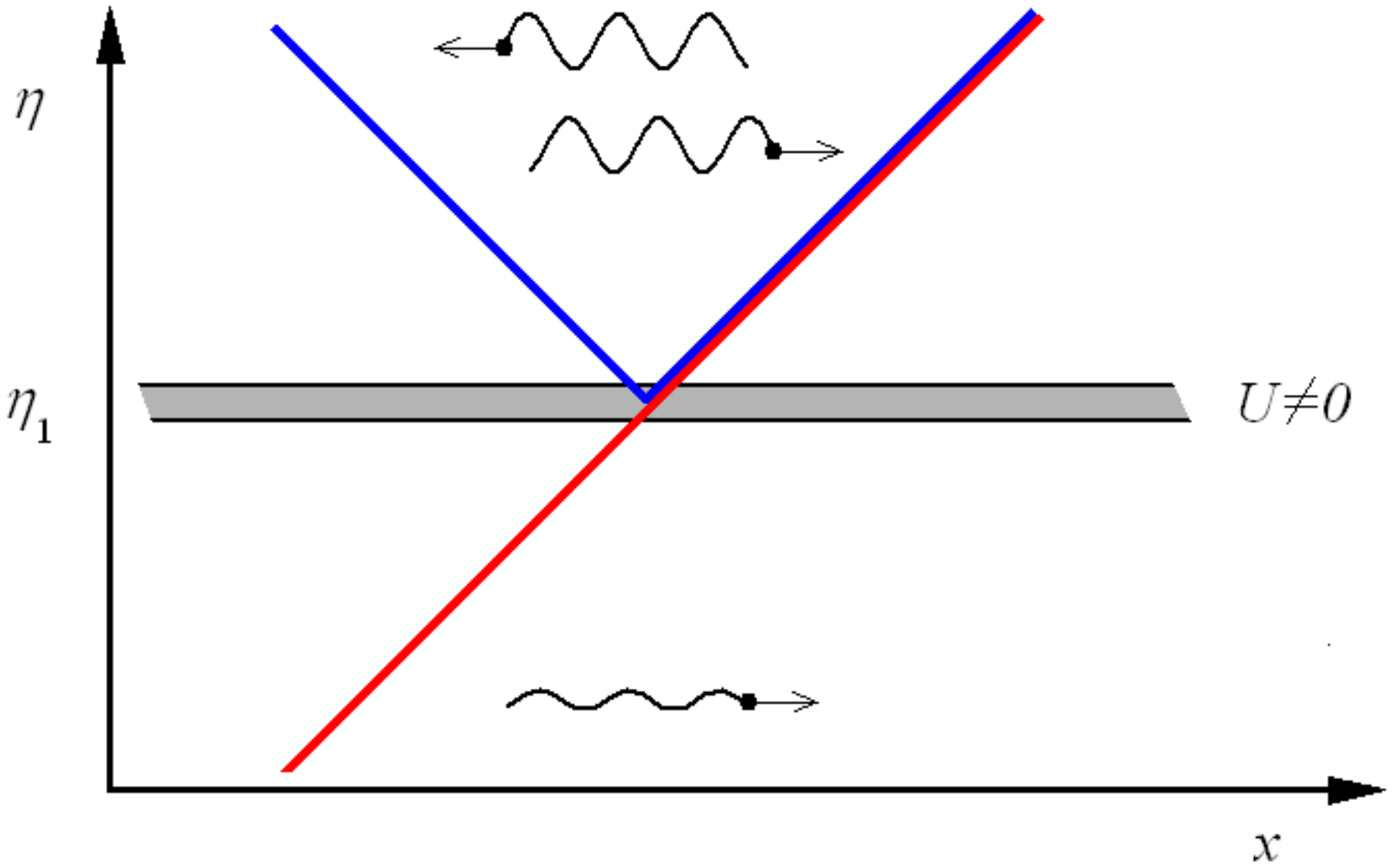
$$\bar{q}'' + (\omega^2 - U)\,\bar{q} = 0$$

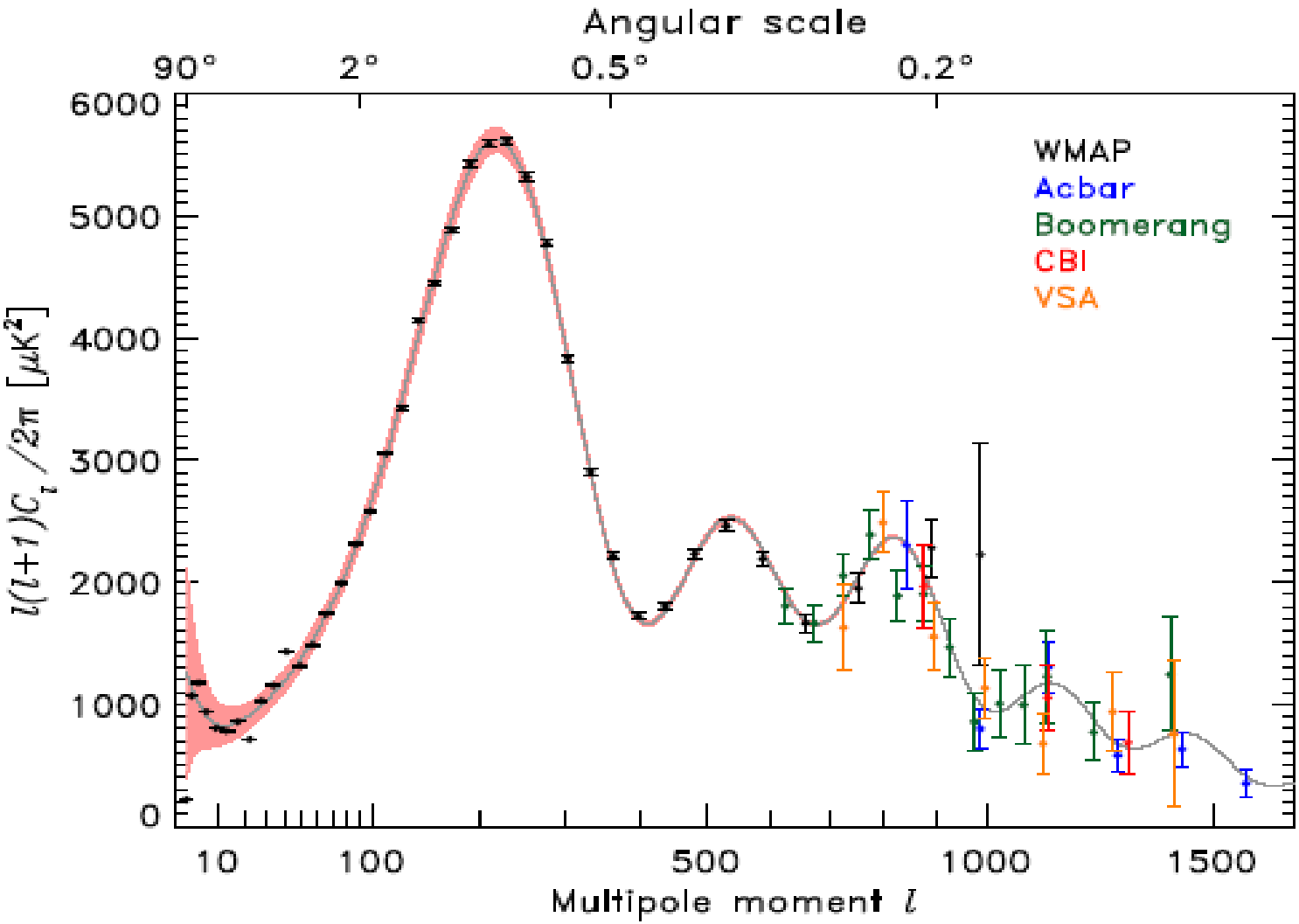
$|f| \ll 1$ adiabatic zone (free oscillations)

$$q \propto (\alpha\sqrt{\beta})^{-1} \exp\left(-i\int \omega d\eta\right)$$

$f \geq 1$ parametric zone (freezing)

$$q \propto \text{const}$$


η
η_1
$U \neq 0$
x



In the beginning was sound
And the sound was of Big Bang

Universal result

$$T = \frac{H^2}{M_P^2} \quad , \qquad \frac{T}{S} = 4\gamma$$

Expected (T/S < 0.1):

$$H < 10^{13}\,\text{Gev} \quad , \quad \gamma < 0.02$$

lesson 4: evidence for DM

Origin of dark matter is related to baryonic asymmetry

$$\varepsilon_b \approx \varepsilon_{DM}$$

lesson 5: evidence for DE

Structure argument (LSS + CMB)

$$\rho_m / \rho_c < 0.3$$

More than 70% of energy of the Universe stays unclustered → $p \approx -\rho$ (dark energy)

Dark energy **– weakly interacting physical essence permeating space of the visible Universe**

A superweak field

no difference with inflaton

(different parameters)

lesson 6 : evolution of the Universe

* for 14 Gyr – two inflationary stages
* there could be more than two, same reasons
* simple cause of inflation – weak massive field
* inflation creates and restores Hubble flows

History of the Universe is a story of origin and decay of massive fields

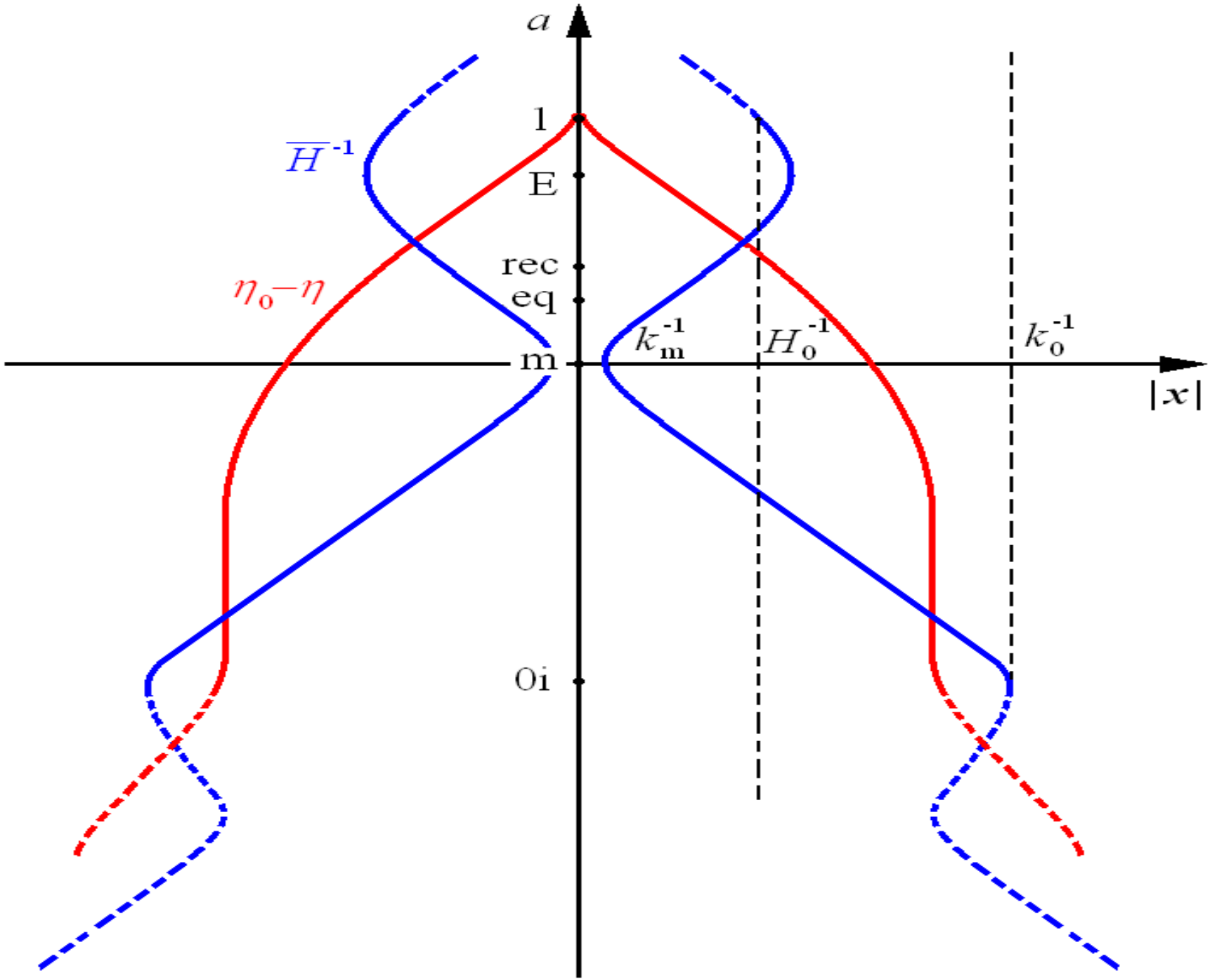
Creation of the Universe is creation of Hubble flow

$$\vec{v} = H\vec{r} \ , \qquad H = \dot{a}/a$$

$\ddot{a} > 0$ *(anticollapse or inflation)*

Formation of structure is destruction of Hubble flow

$\ddot{a} < 0$ *(collapse: halos, black holes)*


a
1
E
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m
0i
$\overline{H}^{-1}$
$\eta_0 - \eta$
k_m^{-1}
H_0^{-1}
k_0^{-1}
|x|

lesson 7: cosmogenesis

Universe

Multiverse

What is the origin of ultrahigh densities?

And why does the expansion occur ?

Gravitational instability (tidal interaction)

Cosmogenesis paradigms

Cosmological postulate (homogeneity and isotropy)

Creation of universe from nothing (false vacuum)

Eternal inflation (sub-Planckian curvature/density)

Inflation does not explain cosmological symmetry

The cosmological postulate is changed for two others:

(1) *ultrahigh curvature/densities*

(2) *impulse launching expansion*

Our paradigm of cosmogenesis

Daughter universes are formed inside
T-regions of black/white holes
in the process of collapse
of stars, clusters and other compact astrophysical objects at final stages of their evolution in the maternal universe

Basics

(1) ***Ultrahigh curvature/densities are reached in the course of gravitational collapse***

(2) ***Impulse launching the expansion results from the inversion of collapse (tidal forces)***
Integrable singularities ***in the T-regions of B/W holes allow to extend geodesics beyond r=0 and construct geodesically complete geometry***

(3) ***Cosmological flow forms from the matter generated through quantum-gravitational process at high curvature outside the collapsing body***
It may become quasi-Hubble if driven by inflation

Integrable singularities

General metrics $R^2 x S^2$ in the Euler coordinates:

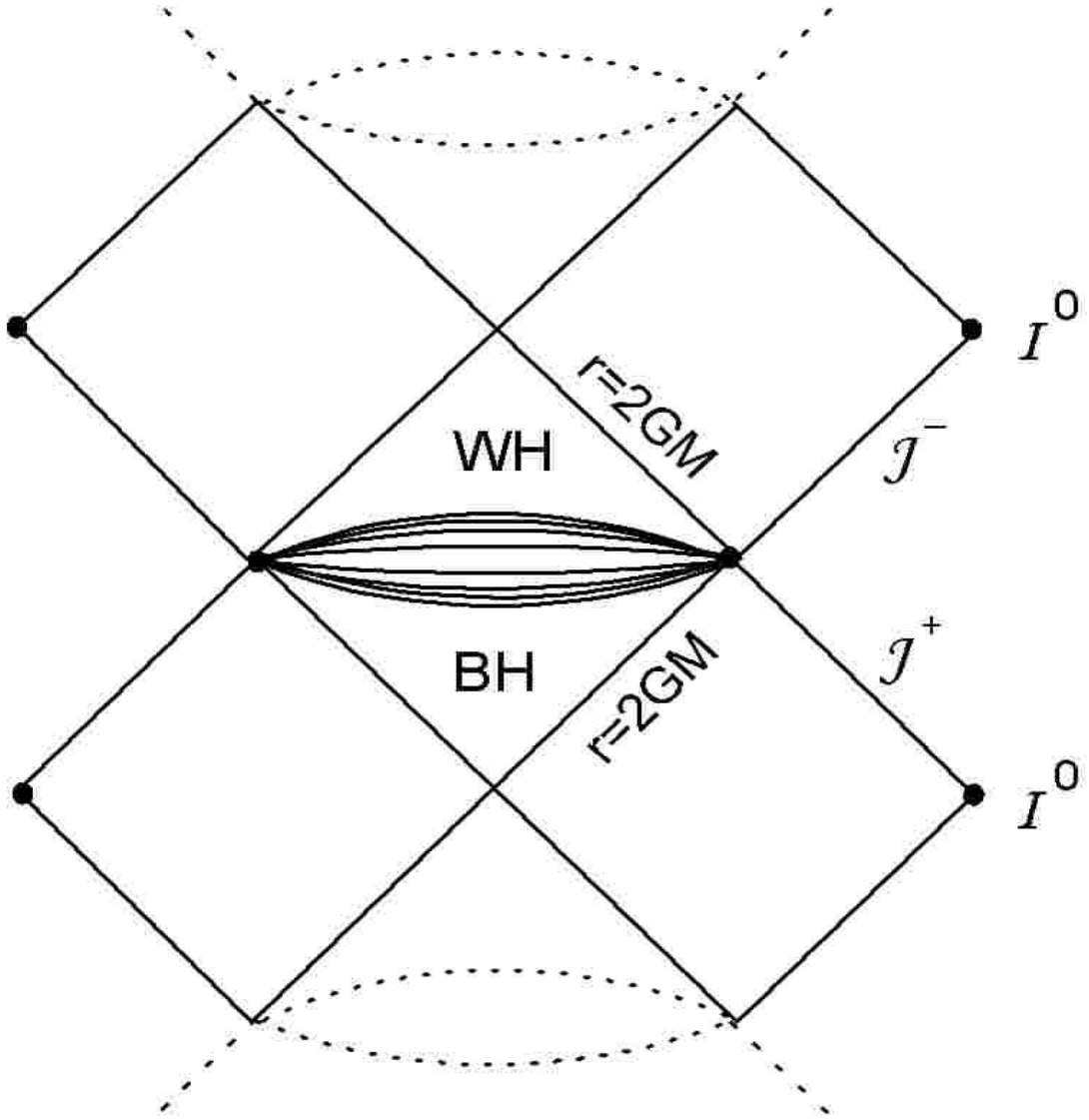
$$ds^2 = N^2(1+2\Phi)dt^2 - \frac{dr^2}{1+2\Phi} - r^2 d\Omega$$

N, Φ – real finite functions of (t,r)

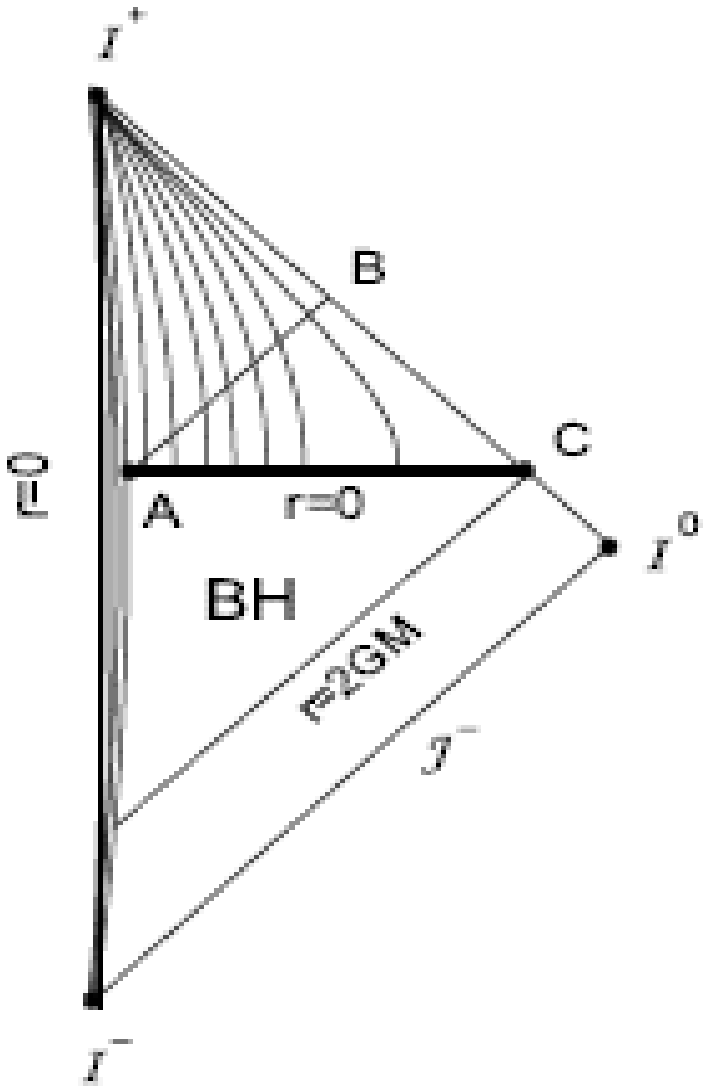
$$\Phi = -\frac{G\, m(t,r)}{r}, \qquad m(t,0) = 0$$

$$m(t,r) = 4\pi \int_0 T_t^t r^2 dr$$

integrable at r = 0



Eternal black/white hole



Astrogenic universe (ABC – homogeneous cosmology)

Conclusions

Extrapolating the CSM in the past let everyone see that early Universe was deterministic and restore the initial conditions

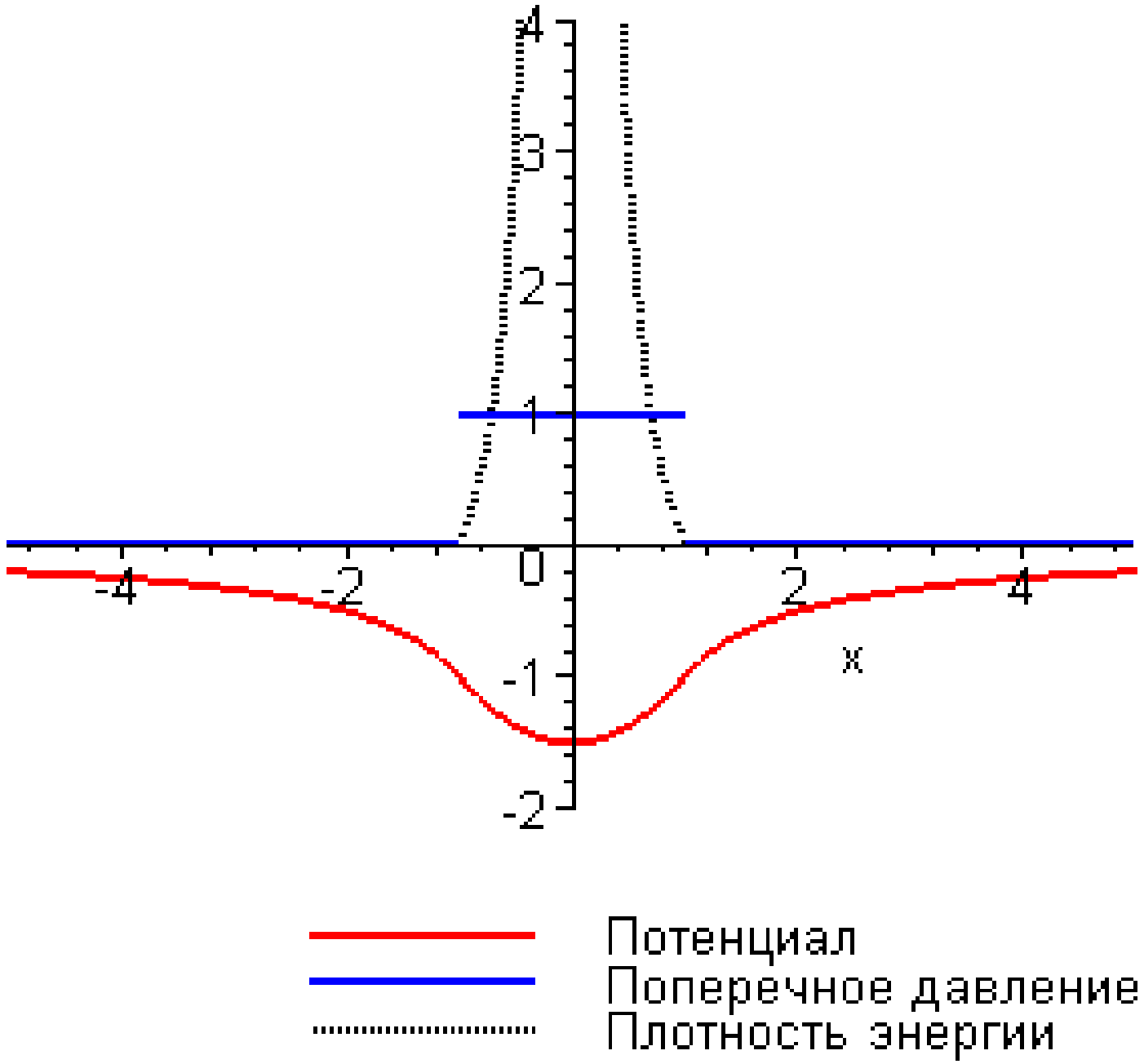
(1) Ultrahigh curvature/densities

(2) Impulse launching the expansion

(3) Quasi-Friedmannian symmetry

Astrogenic cosmology

Having come to the end of their evolution in the maternal universe collapsing compact objects give birth to numerous daughter worlds


4
3
2
1
0
-1
-2
-4
-2
2
4
x
Потенциал
Поперечное давление
Плотность энергии