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Early Universe Black Holes Cosmogenesis

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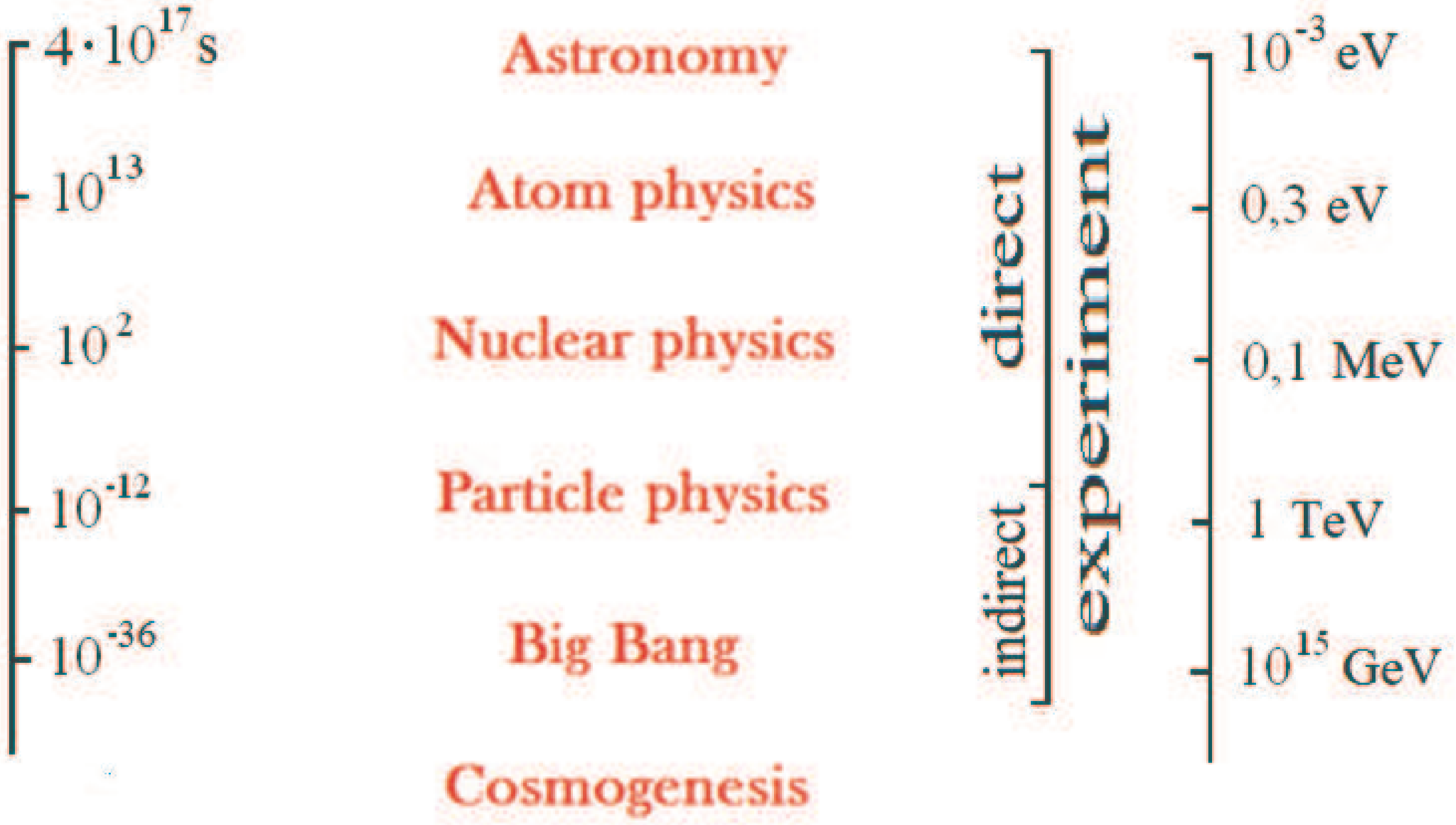
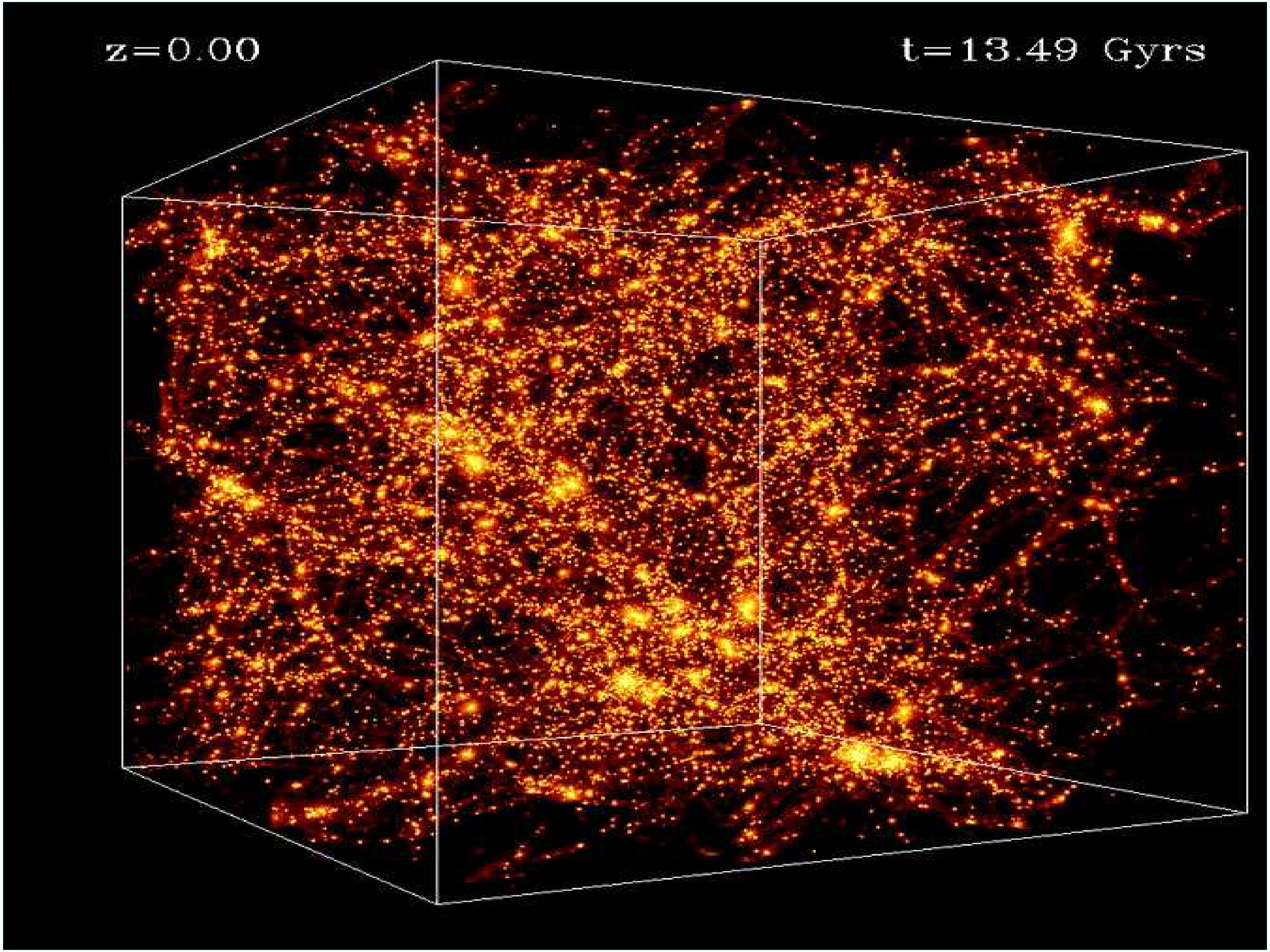
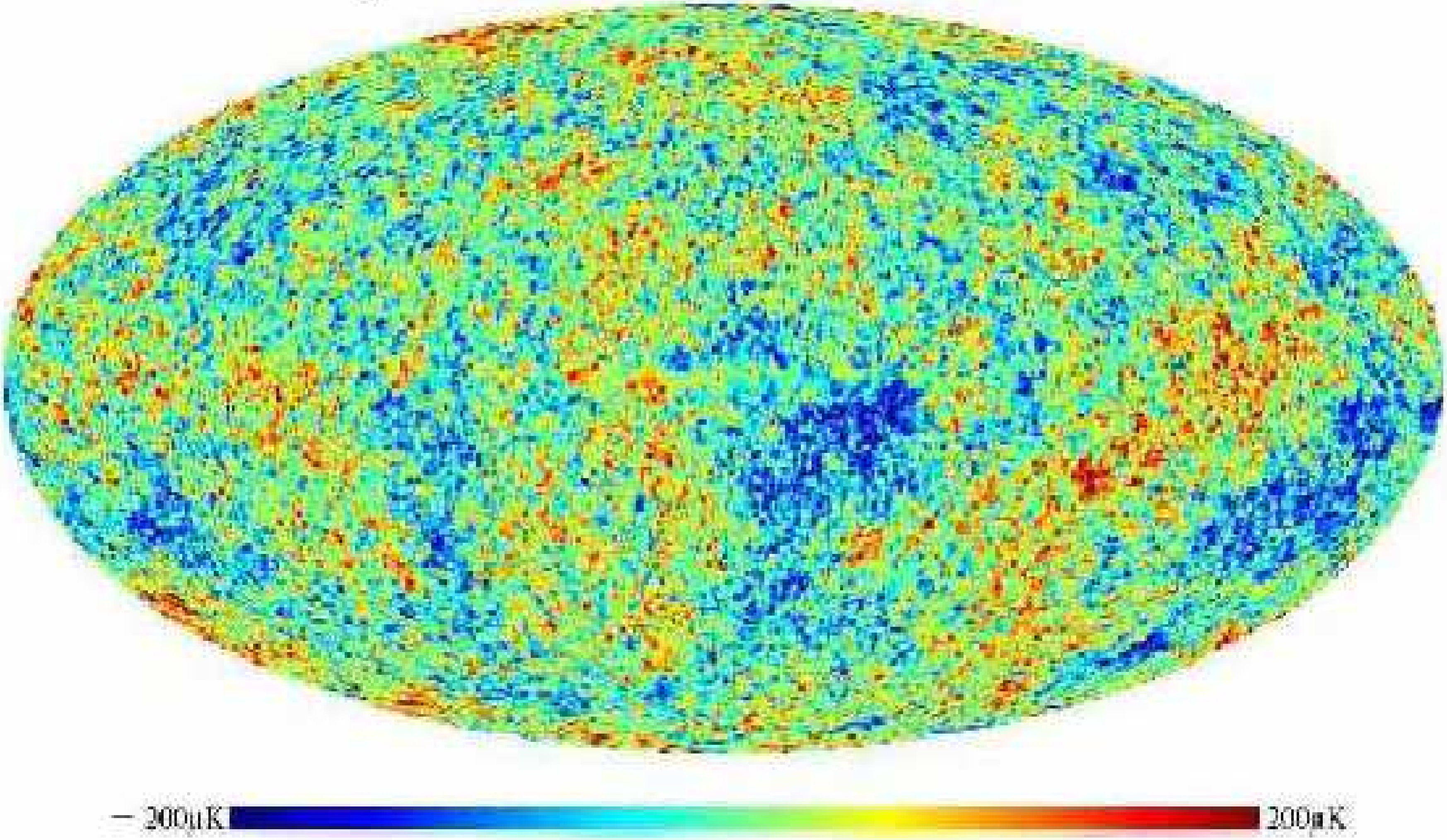
• Extrapolation of CSM in the past
• Creation conditions of the early Universe
• Black-white holes and cosmogenesis

Experimental grounds of CSM




z=0.00
t=13.49 Gyrs

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



WMAP

Geometry of the early Universe

(*structure of metric and stress-energy tensors*)

- 0^{th} order ***Hubble flow*** $a(t)$

- 1^{st} order ***structure***

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

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

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

deterministic early Universe

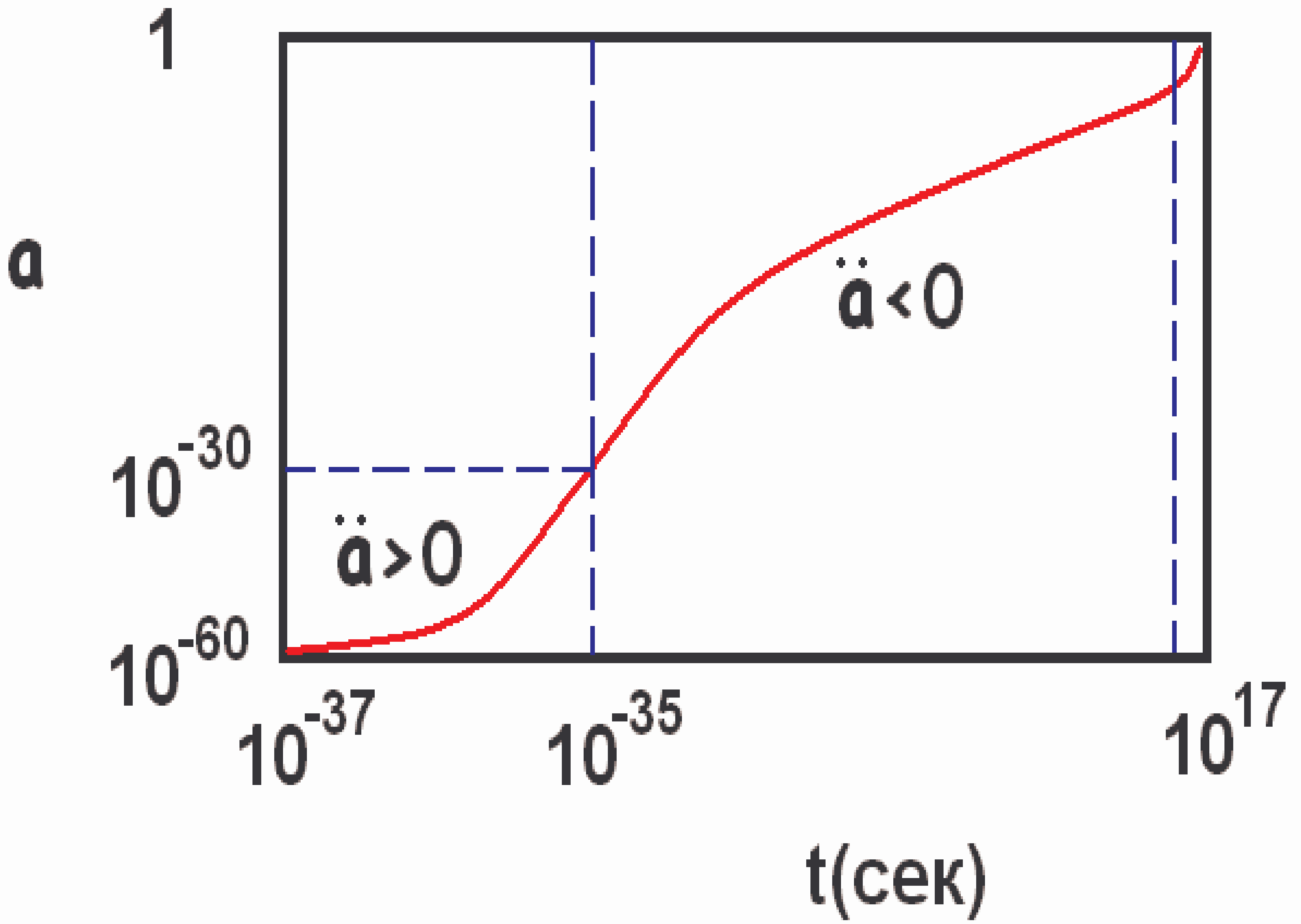
0^{th} order (*algebra*)

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

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

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

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



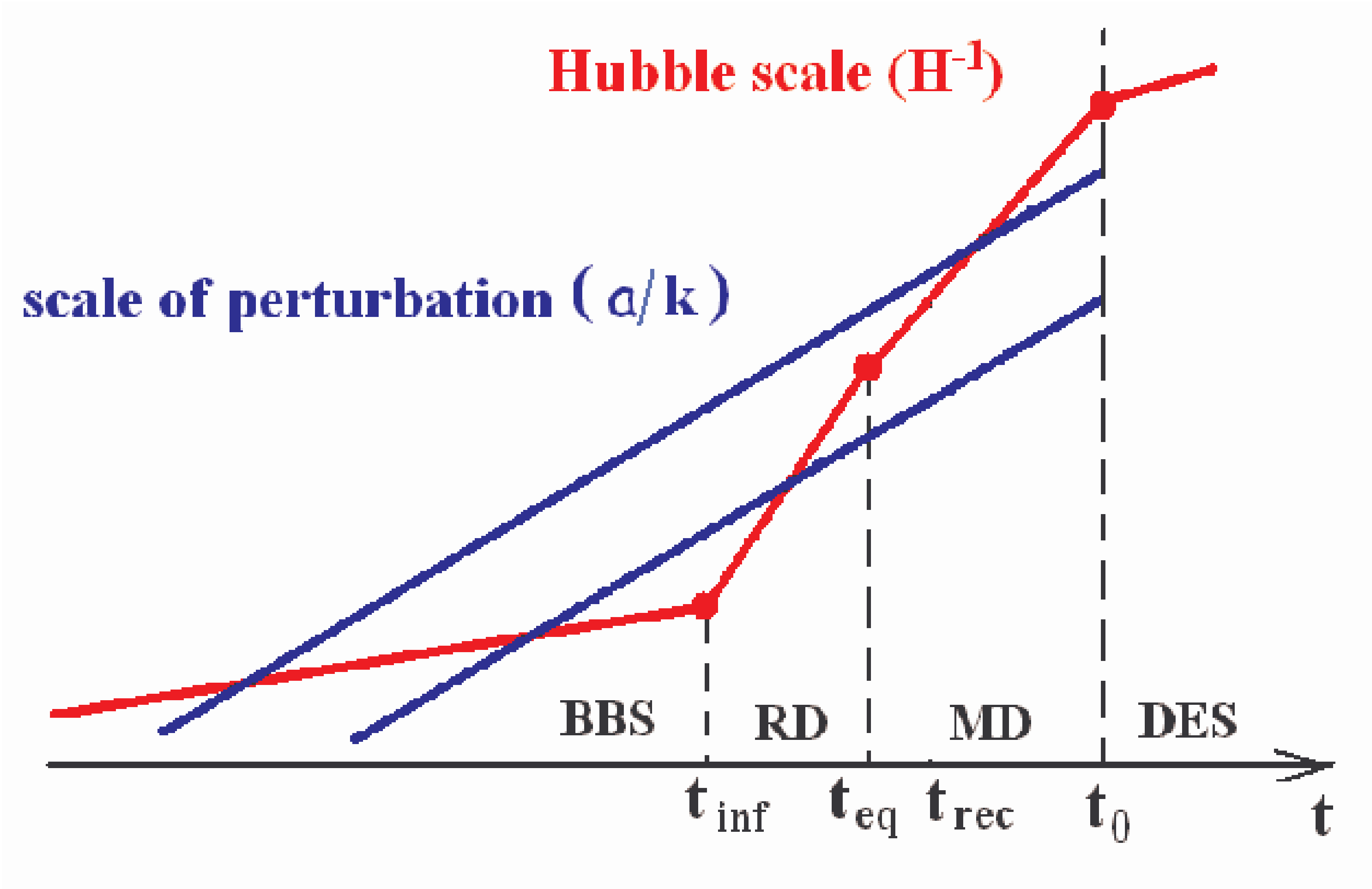
1
a
10^{-30}
10^{-60}
$\ddot{a}>0$
$\ddot{a}<0$
10^{-37}
10^{-35}
10^{17}
t(сек)

Size of the Universe

In the beginning of radiation-dominated stage the physical size of the Universe is as large as 10^{30} the fundamental scale

Such a large factor can be explain by existence of preceding short-time inflationary stage ($\gamma < 1$)

Causality



Hubble scale (H^{-1})
scale of perturbation (a/k)
BBS
RD
MD
DES
t_{inf}
t_{eq}
t_{rec}
t_0
t

1st order (*oscillators*)

Gaussian perturbations

S → origin of matter structure
(galaxies, clusters, voids..)

S+T+V → origin of CMB structure
(anisotropy and polarization)

T/S < 0,1

Quantum-gravitational origin of primordial cosmological perturbations

creation of massless fields from vacuum

in non-stationary gravitational field

- Matter creation (Grib, Starobinsky 1970s)
- Generation of T-mode (Grishchuk 1974)
- Generation of S-mode (V N L 1980)

Problem of generation of S and T modes of cosmological perturbations in Friedmann model is reduced to quantum-mechanical problem of elementary oscillators $\omega=\beta k$ in external non-stationary field $\alpha(\eta)$ in Minkowsky space $(\eta, \mathbf{x})$

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

q_T - transverse-traceless component of metric tensor

$$\alpha^2 = \frac{a^2}{8\pi G}, \qquad \beta = 1$$

q_S - superposition of longitudinal gravitation potential and velocity potential

$$\alpha^2 = \frac{a^2\gamma}{4\pi G\beta^2}, \qquad \beta = \frac{c_s}{c}$$

Elementary oscillators

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

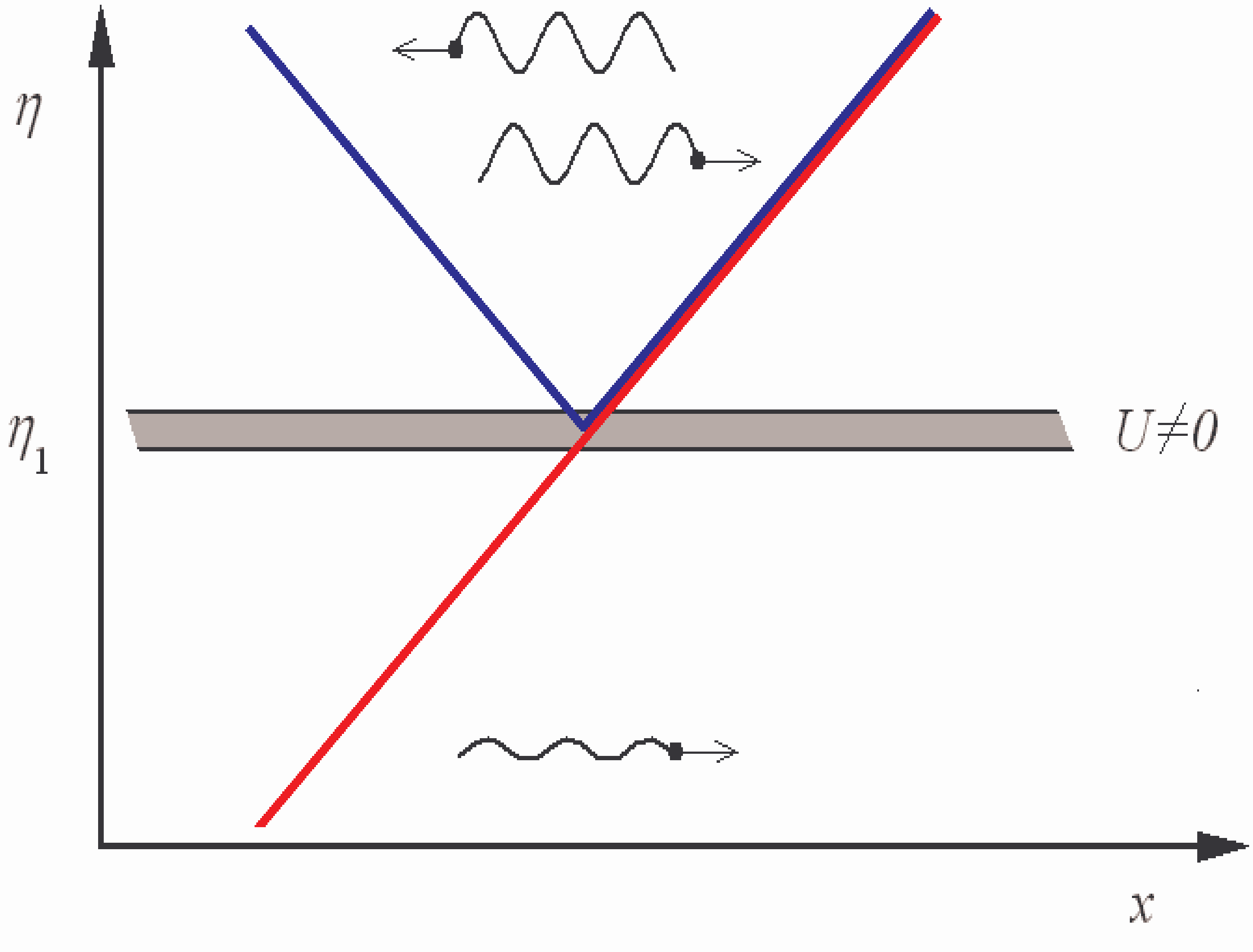
$$\bar{q}'' + (\omega^2 - U)\ \bar{q} = 0$$

$|f| << 1$ Adiabatic zone (free oscillations)

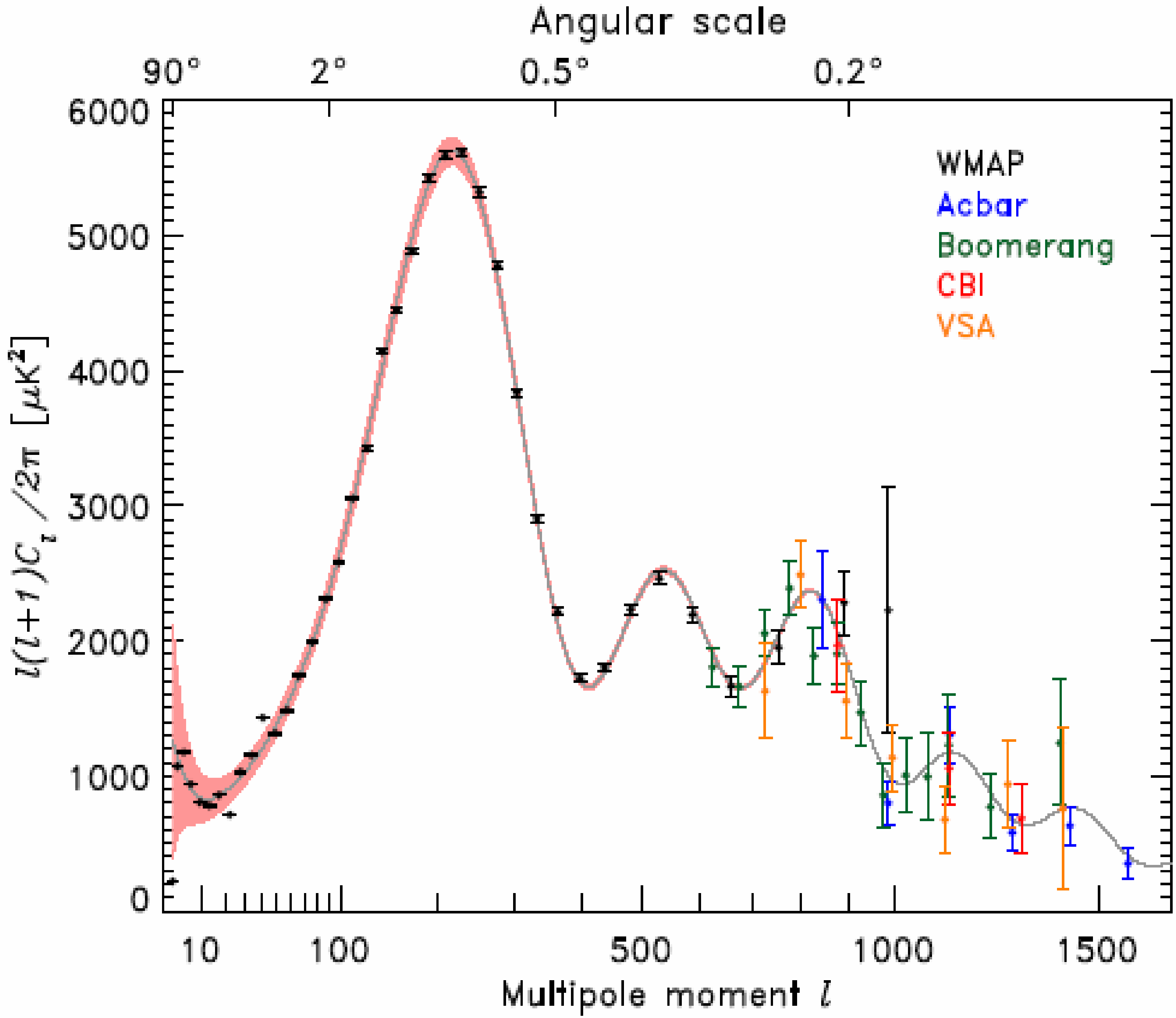
$$q \propto (\alpha\sqrt{\beta})^{-1} \exp\left(-i\int \omega d\eta\right)$$

$f \geq 1$ parametric zone (freeze out)

$$q \propto \mathrm{const}$$



η
η_1
$U\neq 0$
x



Angular scale
90°
2°
0.5°
0.2°
6000
5000
4000
3000
2000
1000
0
WMAP
Acbar
Boomerang
CBI
VSA
l(l+1)C_l /2π [μK²]
10
100
500
1000
1500
Multipole moment l

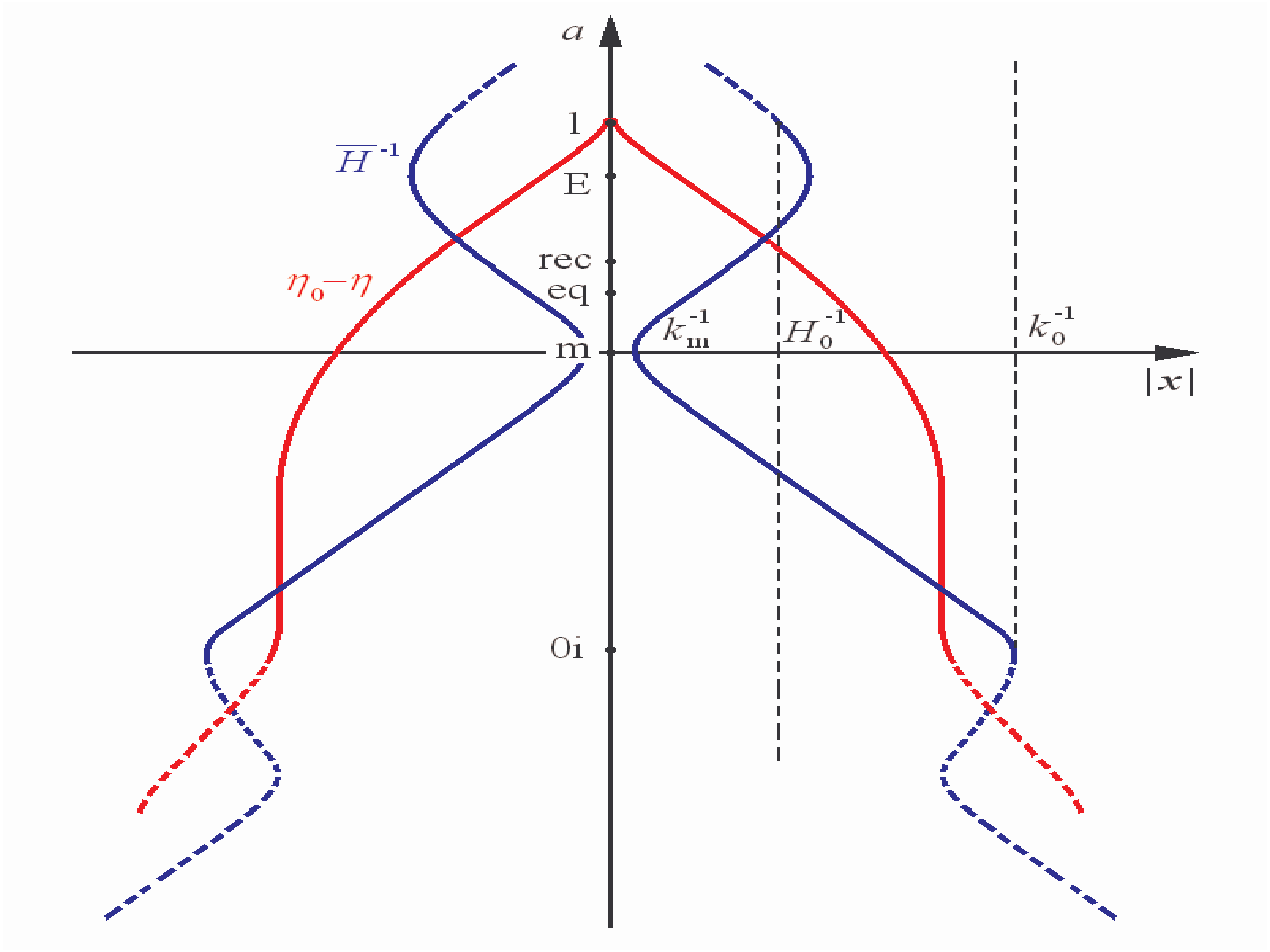
General result

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

expectation (T/S < 0,1):

$$H < 10^{13}\ \mathrm{GeV}\ , \quad \gamma < 0.02$$

Inflationary Big Bang stage ($\gamma < 1$)



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

Creation of universe is creation of Hubble flow

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

$\ddot{a} > 0$ *(anti-collapse or inflation)*

Creation of structure is destruction of Hubble flow

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

Universe is deterministic, large and exists short period of time (inflation)

Inflation can not answer the question of initial conditions

How do large densities appear ?
How is cosmic expansion born ?
What is the initial symmetry ?

These are the cosmogenesis questions

Cosmogenesis paradigms

Cosmological postulate (*universe*: hom.+isot.)

Creation of universe from nothing (‘false’ vac.)

Inflation itself froms Hubble flows (*multiverse*)

Eternal inflation (subplanckian curvature/dens)

Cosmological postulate was changed for two others:

superlarge curvatures/density

launch of expansion of matter

We assume:

Universe is not alone (*Kopernik principle*)

Gravitational generation of the universes

Black hole singularities (collapsing COs)

Analytical continuation beyond singularity

Integrable singularities of BWHs

Our concept of cosmogenesis

New universes are created
in the T-regions of BWHs
produced in the course of collapse
of stars,clusters and other compact
astrophysical objects in the end of
their evolution in parent universes

Answers to cosmogenesis questions

(1) *Superlarge curvatures/densities are reached during gravitational collapse*

(2) *Launch of expansion - collapse inversion*

Integrable singularities forming in T-regions of BWHs, allow to continue geodesics via $r = 0$ & to reconstruct geodesically complete geometry

(3) *Quasi-Hubble flows form from the matter created quantum-gravit. inT-regions of BWHs*

Integrable singularities

(metrics without punctional points)

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

N, Φ – *real finite functions (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 singularity r = 0

Black-white hole

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

$$m = 4\pi \int_0 \varepsilon(r) r^2 dr \rightarrow M \rightarrow$$

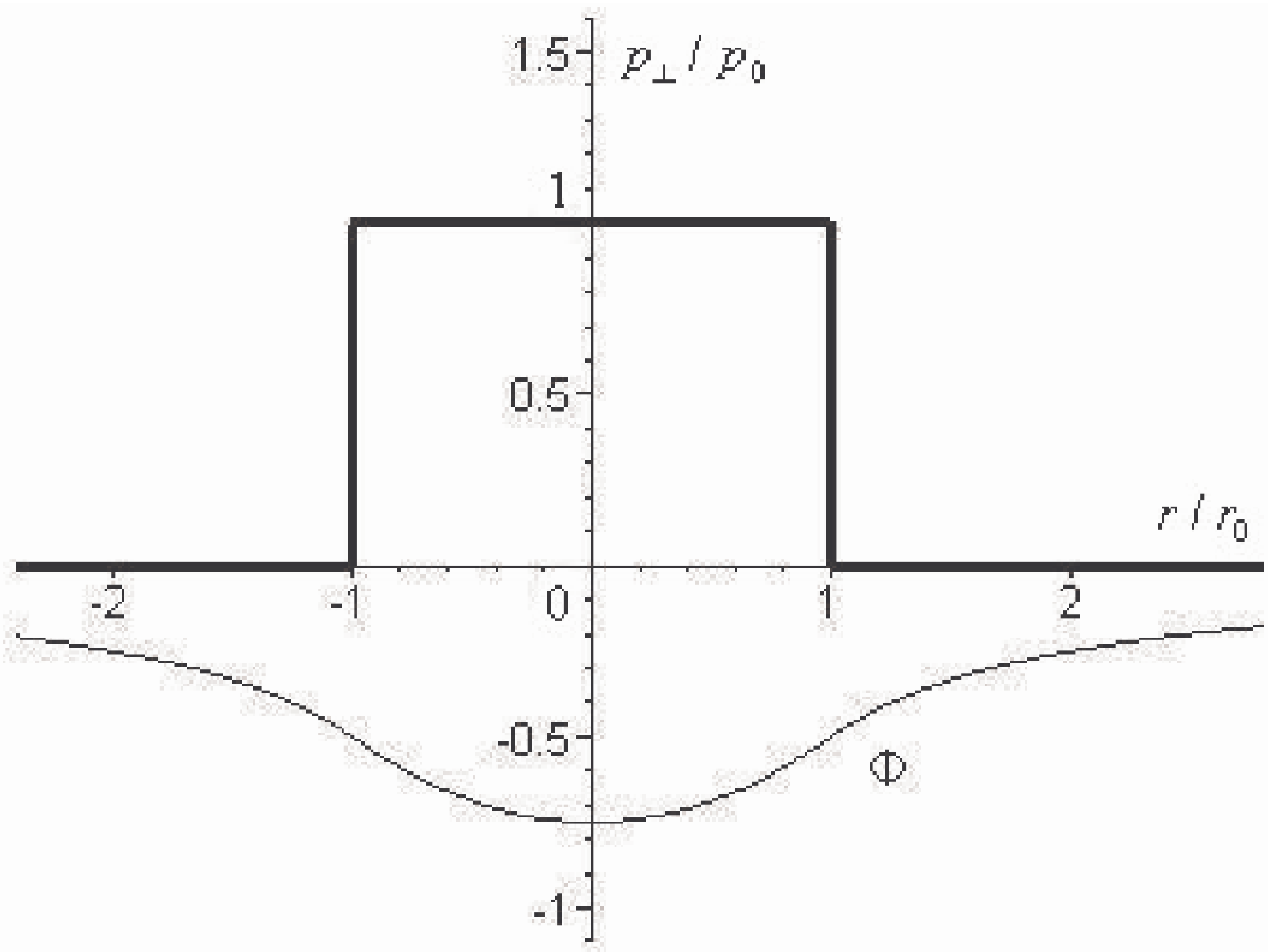
$$= M - 4\pi \int_{r_0} p(r) r^2 dr = -4\pi \int_0 p r^2 dr$$

White hole (r < 0) is the extension of black hole (r > 0) under condition $\Phi = 4\pi G p r^2 = const$ *at r=0*

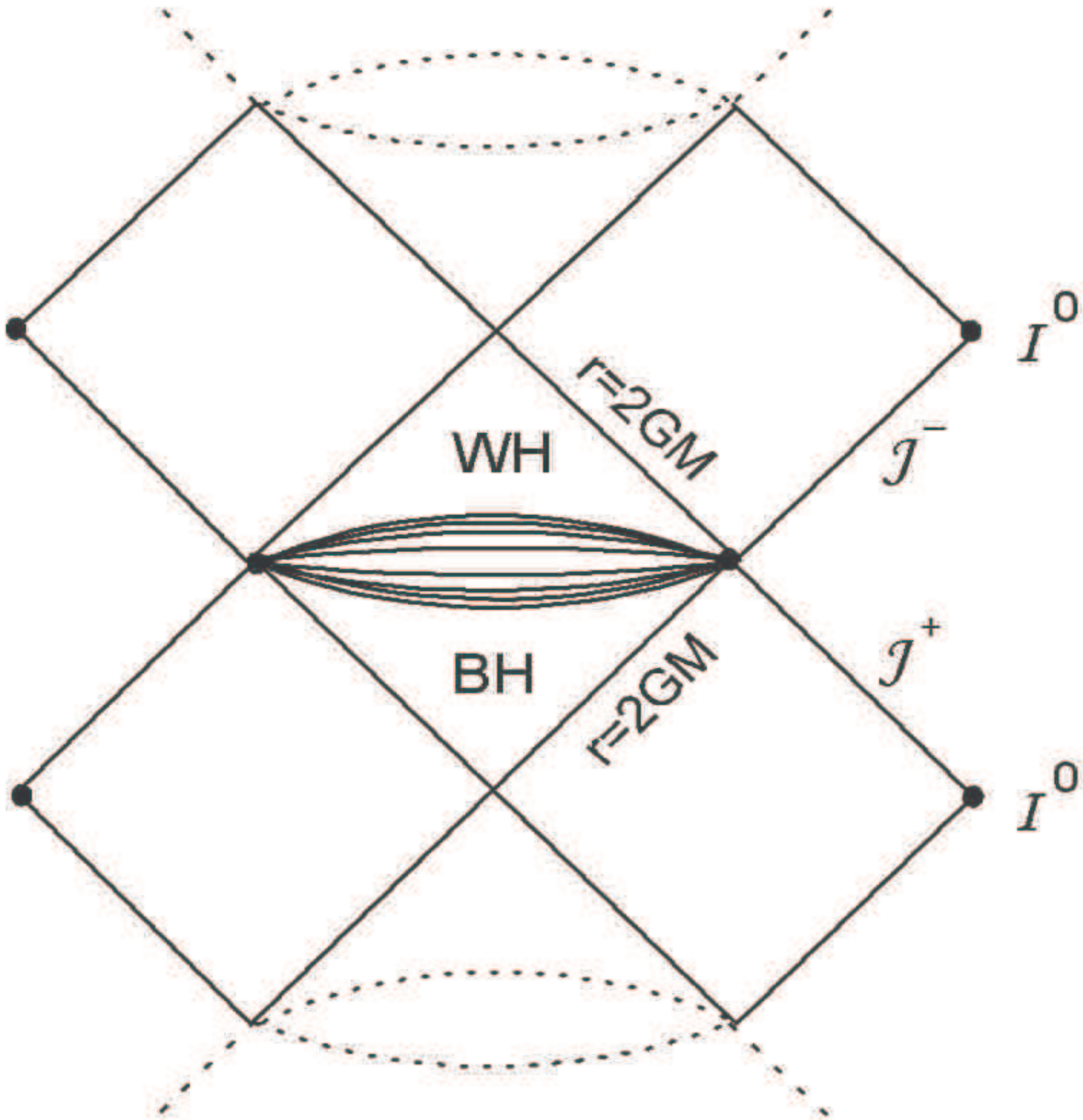
$$\frac{d\left(\varepsilon r^2\right)}{r dr} = -2 p_\perp$$

$$p_\perp^{(B)} = p_0 \cdot \theta\left(r_0^2 - r^2\right)$$

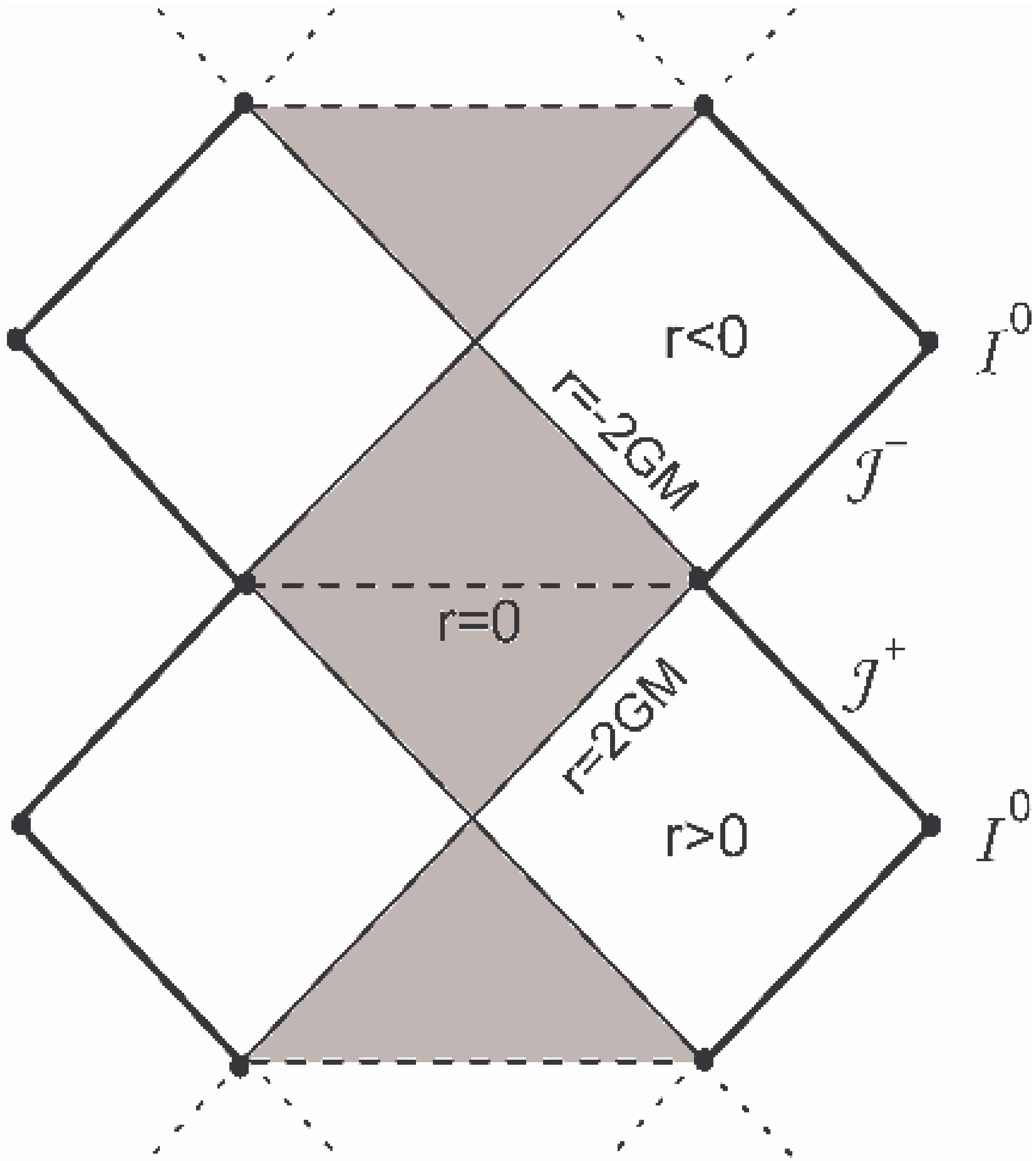
$$p_\perp^{(A)} = p_0 \cdot \theta\left(r r_0 - r^2\right) - p_1 \cdot \theta\left(-r\right)$$



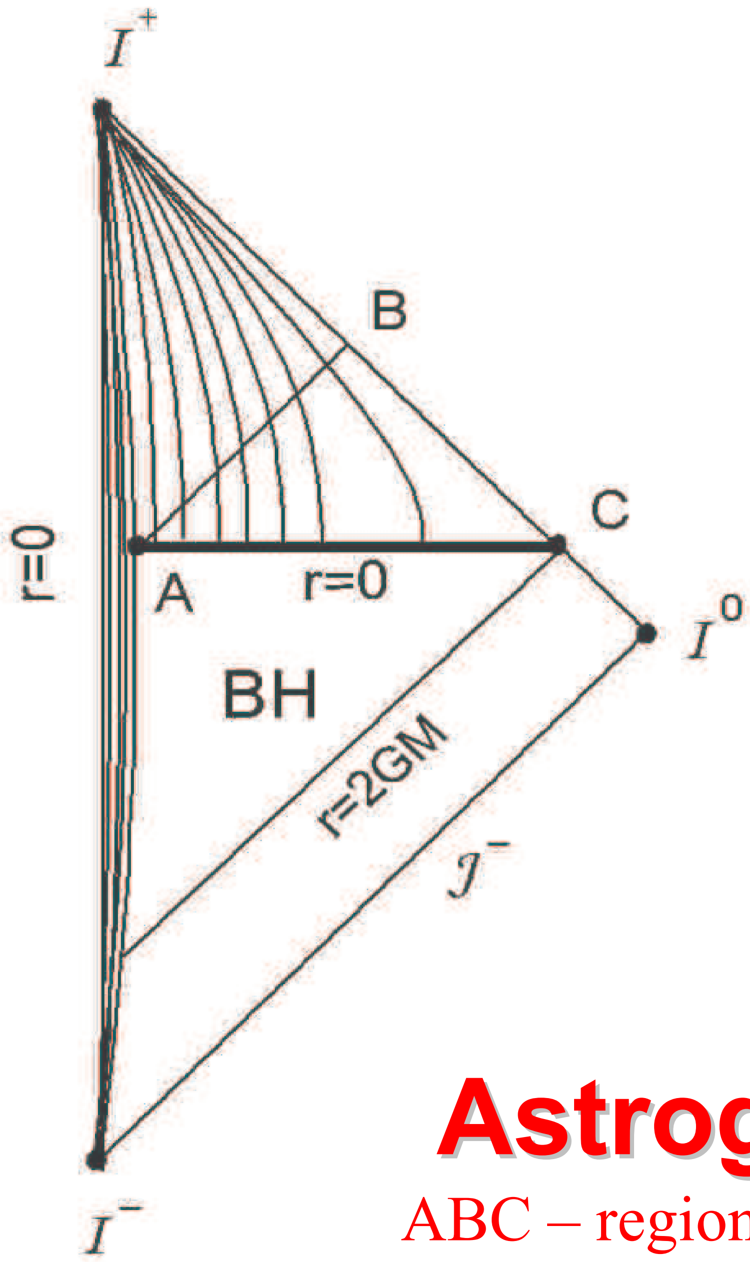
1.5
$p_\perp / p_0$
1
0.5
r / r_0
-2
-1
0
1
2
-0.5
Φ
-1



I^0
r=2GM
WH
$\mathcal{J}^-$
$\mathcal{J}^+$
BH
r=2GM
I^0



Oscillating BWH

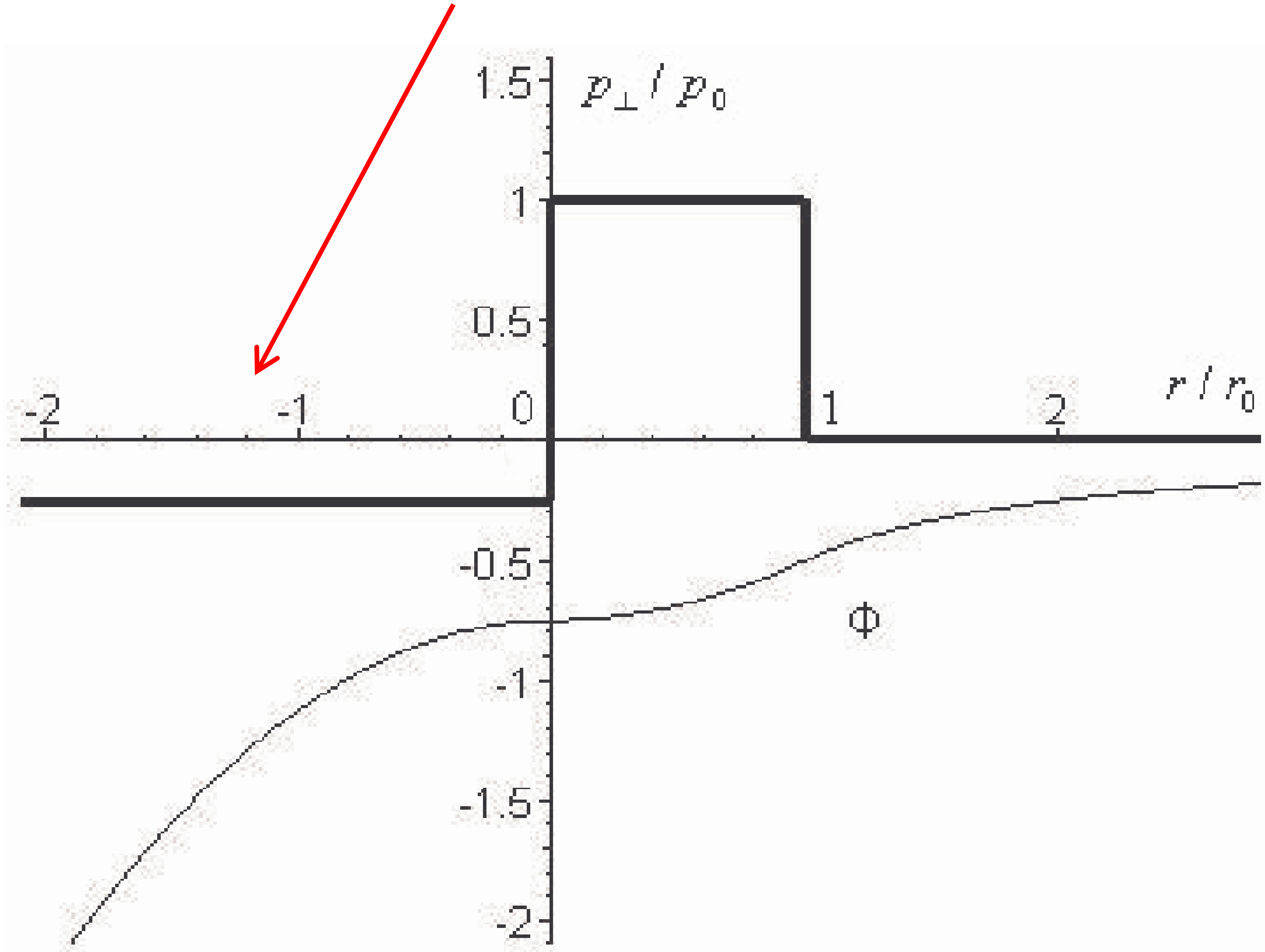


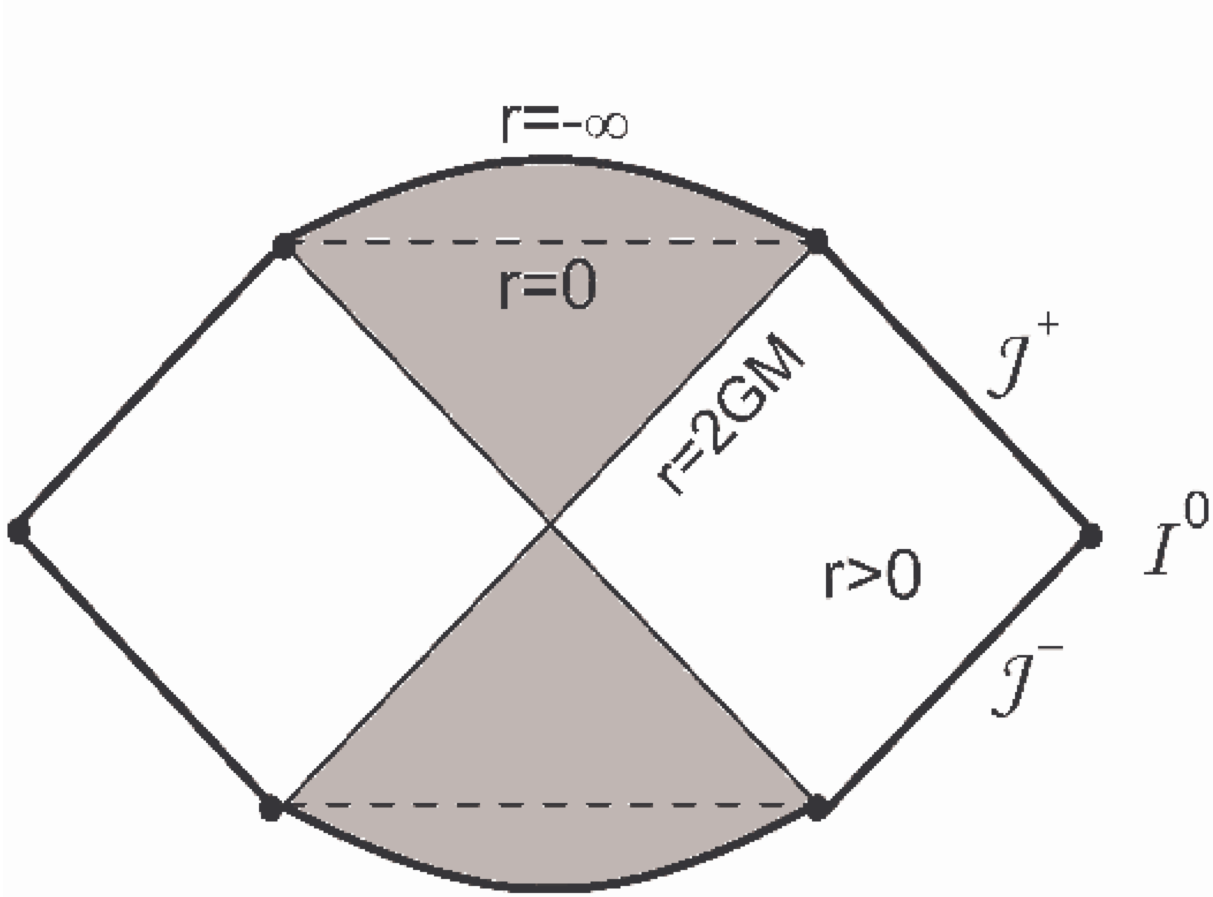
Astrogenic universe

ABC – region of homogeneous cosmology

Solution with inflation

(asymptotically DS)





$$ds^2 = d\tau^2 - \frac{1}{2}\left(\cosh^2(H_1\tau)dt^2 + \frac{\sinh^2(H_1\tau)}{H_1^2}d\Omega\right)$$

$$\tau \geq 0: \qquad r = -\frac{\sinh(H_1\tau)}{\sqrt{2}H_1}, \qquad \varepsilon = \lambda_0 \coth^2(H_1\tau)$$

Results

Extrapolation of CSM in the past allows to reconstruct initial conditions

(1) Superlarge curvature/densities

(2) Launch of expansion of matter

(3) Quasi-Hubble symmetry of flow

Answers to cosmogenesis questions

(1) Superlarge curvatures/densities are reached during gravitational collapse

(2) Launch of expansion of matter arises due to inversion of the collapse

(3) Quasi-Hubble flows form from matter created quantum-gtavitationally in the T-regions of BWHs driven by inflation

Analytical continuation of BH to WH in geometries with integrable singularity

* Integrable singularity is a cusp with unbounded density but zero mass and finite gravitational potential

* Tidal forces are limited

* Geodesics continue from BH to WH

* Integrable singularities are machines for producting matter from gravity

Astrogenic universes

Multi-list universes

A new generation of universes is born inside collapsing objects ending their evolution in the parent universe

Reference

Лукаш В Н, Михеева Е В, Строков В Н «От космологической модели к образованию хаббловского потока» Успехи Физ. Наук **182** 216–221 (2012)

Lukash V N, Mikheeva E V, Strokov V N «From the Cosmological model to the generation of the Hubble flow» *Phys. Usp.* **55** 204–209 (2012)