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Cosmology
&
White Holes
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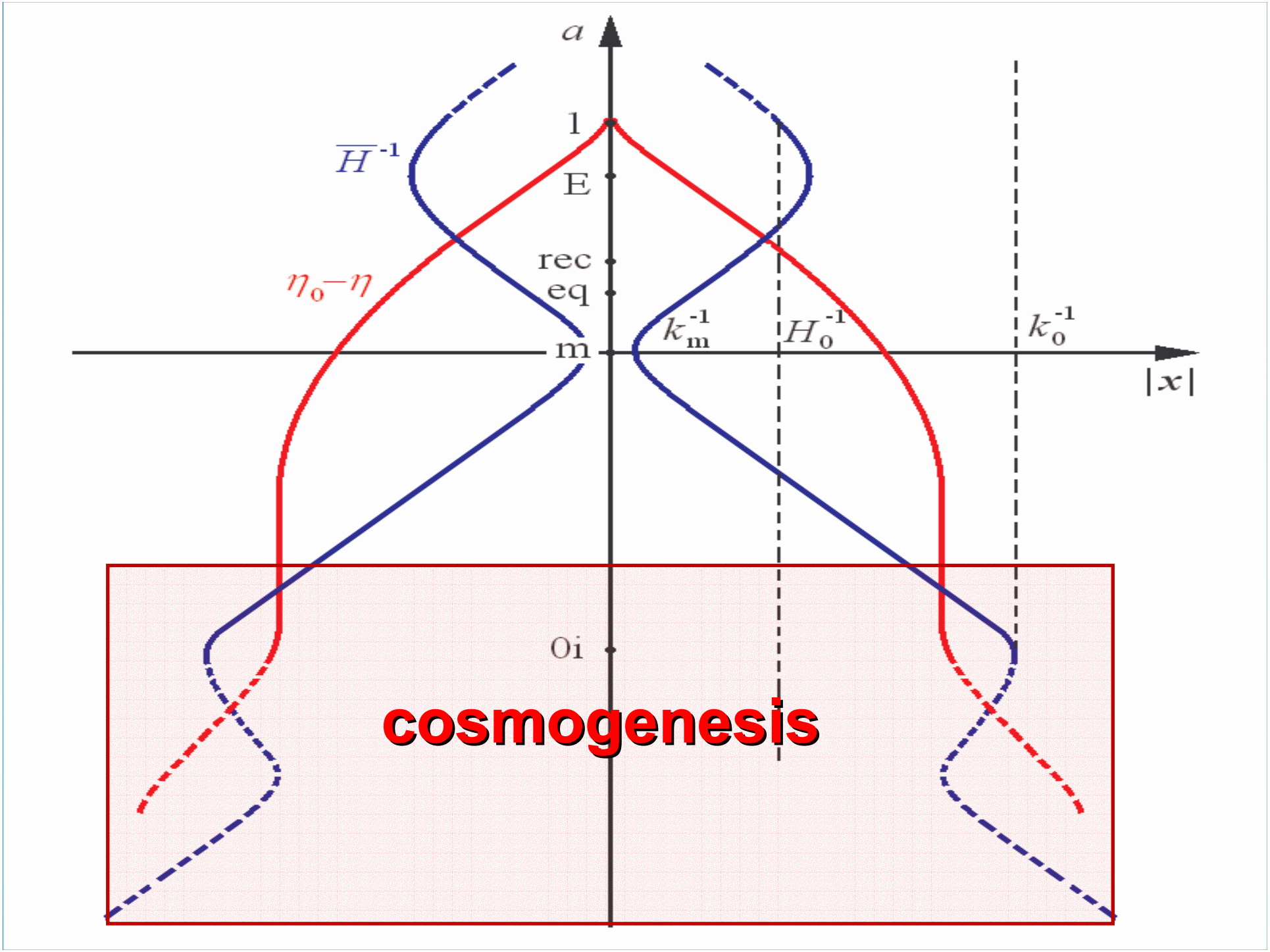
• Extrapolating CSM to the past
• Initial conditions
• Integrable singularities
• Black-white holes
• Astrogenic universes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cosmogenesis

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 (gravitationsl waves) $T(k)$

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

Deterministic early Universe

0th order - *algebra*

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

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

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

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

Size, age & homogeneity

In the beginning of the radiation-dominated epoch physical size of the Universe was as large as 10^{30} the fundamental scale. Such a big size can be explained by existence of preceding short inflationary stage ($\gamma < 1$)

Big size has no relation to cosmogenesis

but the young age and homogeneity do

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 cosmological perturbations

creation of massless degrees of freedom from vacuum in a 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** & **T** modes of cosmological perturbations in Friedmann model is reduced to quantum-mechanical problem of elementary oscillators $\omega=\beta k$ in the external non-stationary field $\alpha(\eta)$ in the Minkowsky space-time (η, x)

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

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

$$\overline{q} = \frac{\alpha}{k} q, \quad U = \frac{\alpha''}{\alpha}, \quad \omega = \beta k$$

$$\boxed{\overline{q}'' + \left(\omega^2 - U\right)\overline{q} = 0}$$

Adiabatic zone (free oscillators)

$$|U| << \omega^2 : \quad q \propto \left(\alpha\sqrt{\beta}\right)^{-1} \exp\left(-i\int \omega\, d\eta\right)$$

Parametric zone (freeze out)

$$|U| \geq \omega^2 : \qquad q \propto const$$

General result

independent of matter properties

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

expectation (**T/S < 0.1**)

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

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

Formation of the Universe is creation of Hubble flow

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

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

Formation of the structure is destruction of Hubble flow

$\ddot{a} < 0$ *collapse:* halo, BH

Universe is deterministic, young and large (inflation)

Inflation does not answer the questions on initial conditions

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

These are the cosmogenesis questions

Cosmogenesis concepts

Cosmological postulate (universe: hom.+isotropy)

Creation of universe from nothing (false vacuum)

Inflation forms Hubble flow (multiverse: homog.)

Eternal inflation (subplanckian curvatures/dens.)

Cosmological postulate was changed for two others

Ultra-high curvatures/densities

Launch of expansion of matter

Cosmogenesis questions are not answered

We assume

Universe is not alone (Kopernikus principle)

Cosmic expansion starts from singularity

Singularities form inside black holes

Creation of effective matter in T-regions

Continuation of matter flow via singularity

Integrable singularities of BWHs

Our answers to cosmogenesis questions

* Ultra-high curvature is reached during gravitational collapse inside black holes

* Launch of expansion - collapse inversion

  Integrable singularity allows to continue matter flow through $r = 0 \rightarrow$ WH source

* Cosmological outflow forms from the effective matter created inside BWH

  Homogeneity in T-regions of BWHs

Integrable singularities

(metrics without singular points)

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

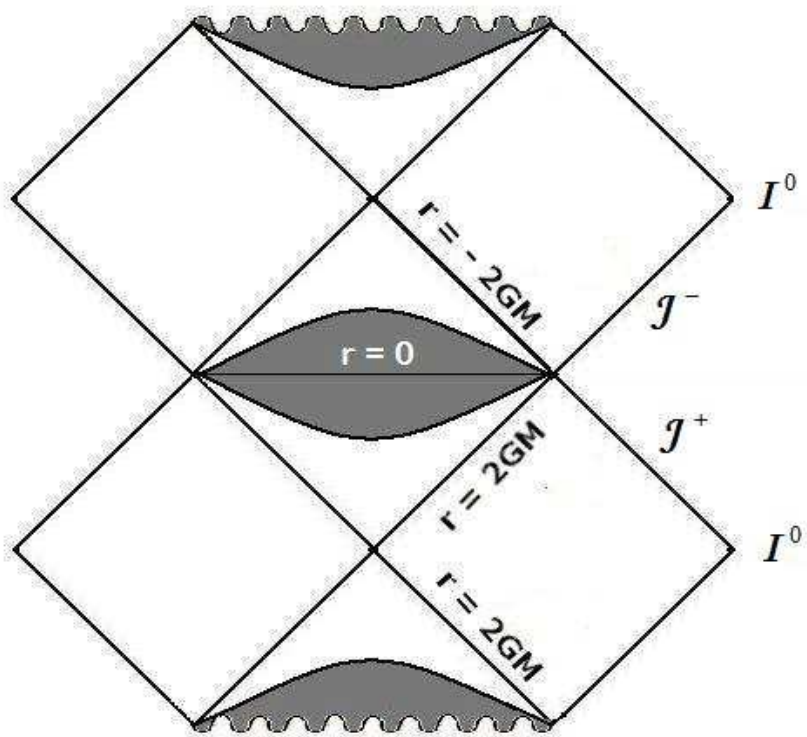
N, Φ – *real and finite functions of* (t,r)

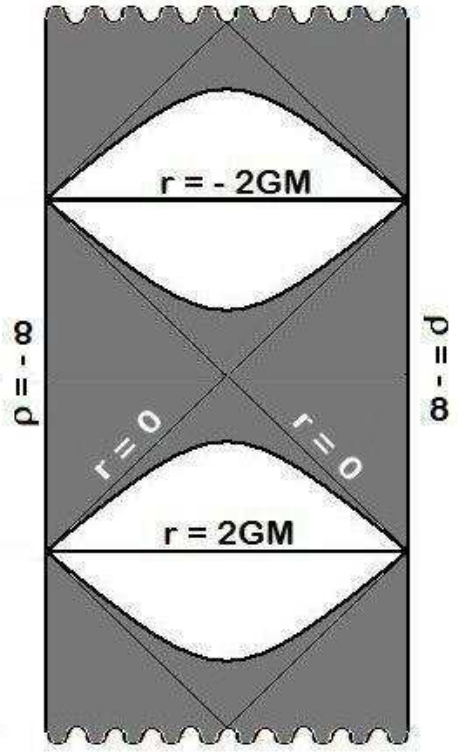
$$\Phi = -\frac{Gm(t,r)}{r}, \quad m(t,0) = 0$$

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

Integrable singularity *r = 0*

Black-white hole





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

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

Finite tidal forces in matter

$$R_{\hat{t}\hat{r}\hat{t}\hat{r}} = \Phi'' \,, \qquad R_{\hat{t}\hat{\theta}\hat{t}\hat{\theta}} = R_{\hat{t}\hat{\phi}\hat{t}\hat{\phi}} = \frac{\Phi'}{r}$$

$$R_{\hat{\theta}\hat{\phi}\hat{\theta}\hat{\phi}} = -\frac{2\Phi}{r^2} \,, \qquad R_{\hat{r}\hat{\theta}\hat{r}\hat{\theta}} = R_{\hat{r}\hat{\phi}\hat{r}\hat{\phi}} = -\frac{\Phi'}{r}$$

$$\frac{D^2\xi^i}{d\,r^2} = R_{\hat{r}\hat{i}\hat{r}\hat{j}}\xi^j \propto \frac{GM}{r_0}\xi^i$$

Negative longitudinal pressure: $p < 0$

a model outside the star: $p = -\varepsilon$

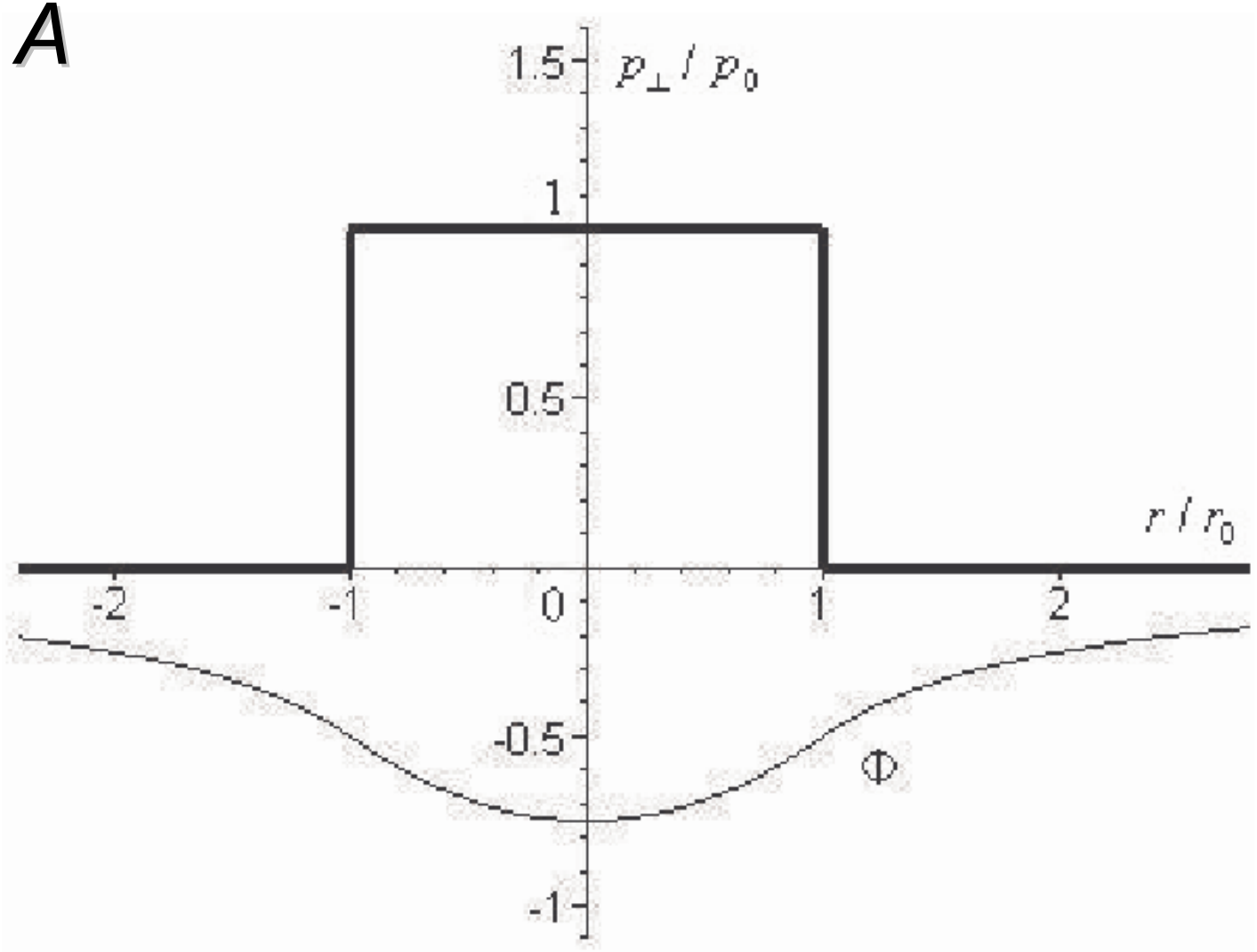
$$\frac{d\left(\varepsilon r^2\right)}{r\,dr} = -2p_\perp$$

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

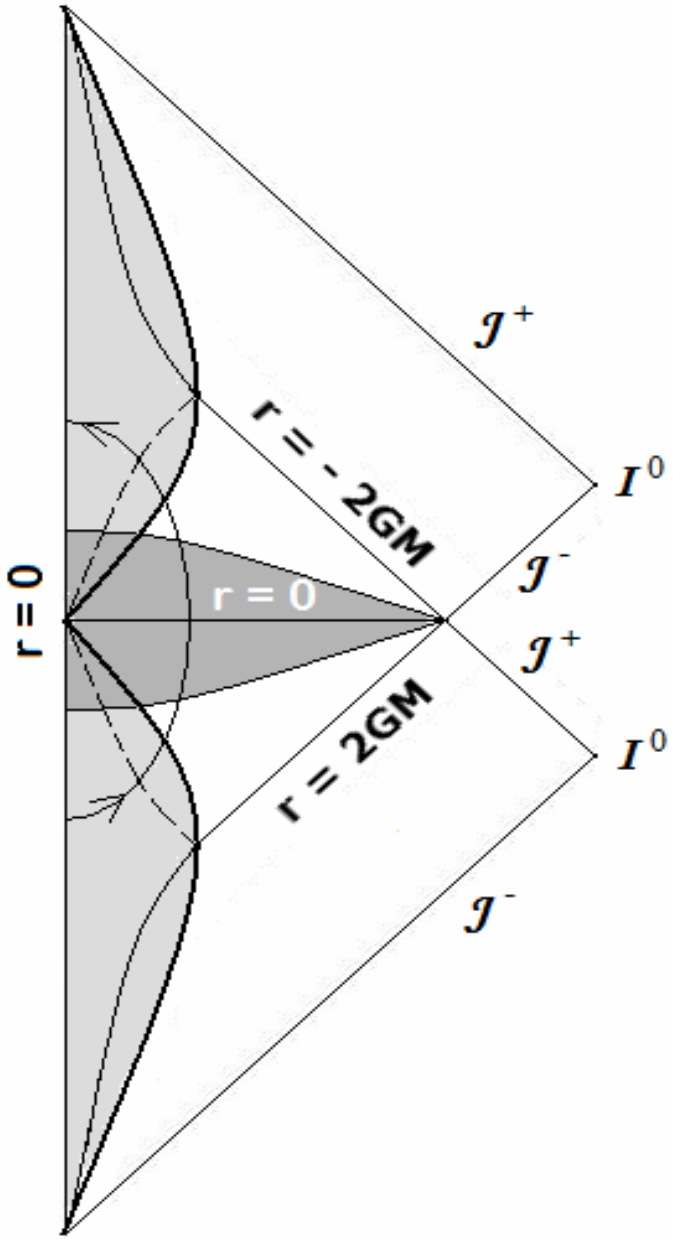
$$p_\perp^{(B)} = p_0 \cdot \theta\left(r r_0 - r^2\right) - p_1 \cdot \theta\left(-r\right)$$

$$0 < r_0 << 2GM$$

A



Astrophysical black-white hole



along line $t = const$:

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

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

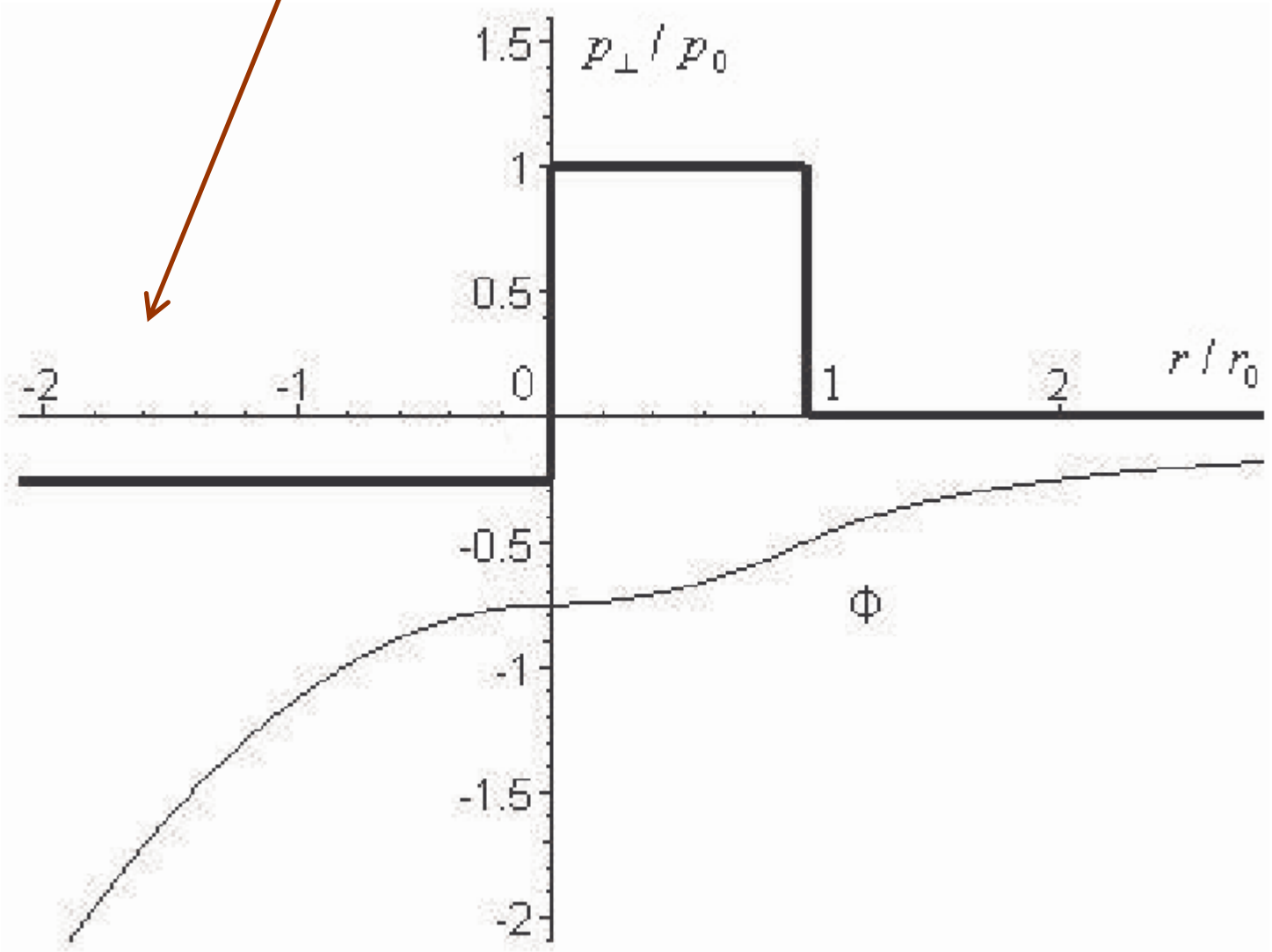
state of effective matter in the star: $\varepsilon + 3p = \lambda_0$

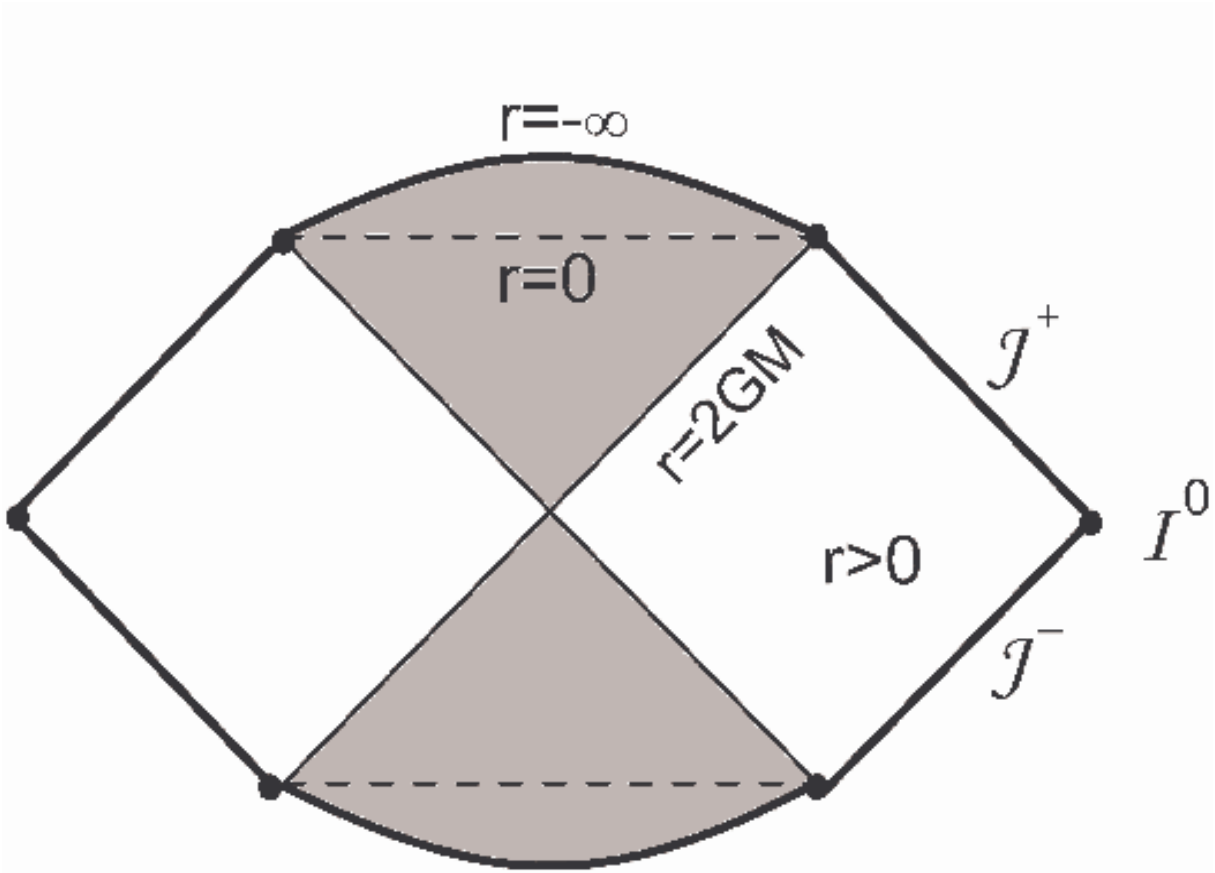
free motion in the bifurcation point: $a \sim t$

Cosmology inside a black hole

(asymptotically de-Sitter universe)

B





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

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

Our concept of cosmogenesis

New generations of universes form in T-regions of BWHs in course of collapses of stars & other compact astrophysical objects in the end of their evolution in parents universes


Conclusions

Extrapolating CSM in the past we reconstruct initial conditions

* Ultra-high curvatures & densities
* Launch of matter expansion
* Quasi-homogeneous matter flow

Answers to cosmogenesis questions

* Ultra-high curvatures & densities are reached during gravitational collapse

* Cosmology is the WH arising as continuation of BH space-time (BWH)

* Cosmological flow consists of matter created quantum-grav.in BWH T-region

Homogeneity is a property of BWH

BWHs are realised as geometries with integrable singularities (IS)

* IS is a cusp (event in time) of zero mass, finite grav.potential, and unbound density

  A mashine producing matter from gravity

* Finite tidal forces in matter geodetic flow

* Geodetic continuation from BH to WH

Astrogenic cosmology (Hyperverse)

New generations of universes are born inside collapsing astrophysical objects ending evolution in parents' universes