Voids in the distribution of galaxies and the cosmological

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Based on
"Λ effect in the cosmological expansion of voids"
H.H. Fliche, R. Triay
arXiv:gr-qc/0607090

Observations

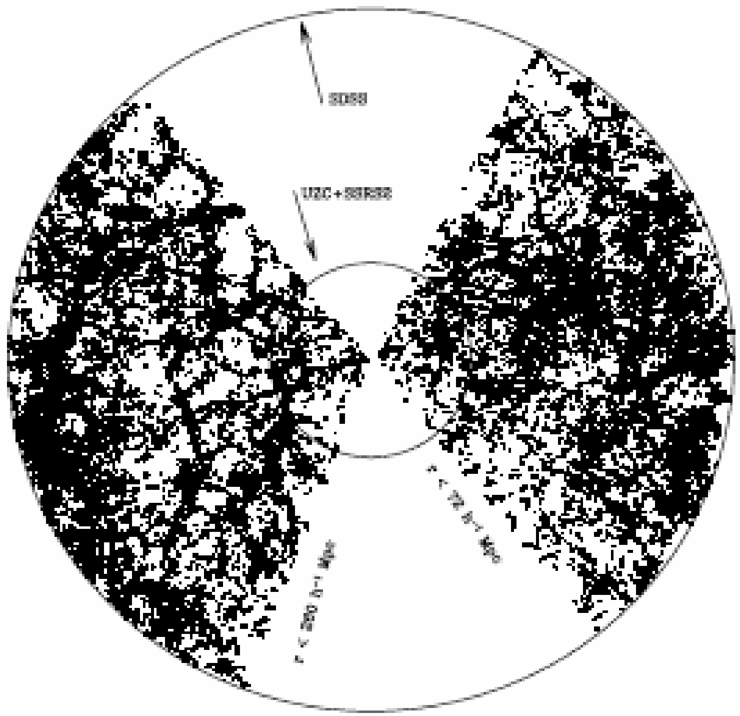
Foam like patterns

M. Jôever, J. Einasto, E. Tago, MNRAS 185,357 (1978)
…**and many others**…

e.g., P.J.E. Peebles adresses the problem
In ApJ 557, 495 (2001)

R.R. Rojas, M.S. Vogeley, F. Hoyle, J. Brinkmann,
ApJ 617, 50 (2004) - **SDSS**

R. B. Tully *etal.* arXiv:0705.4138 - **Local Void**

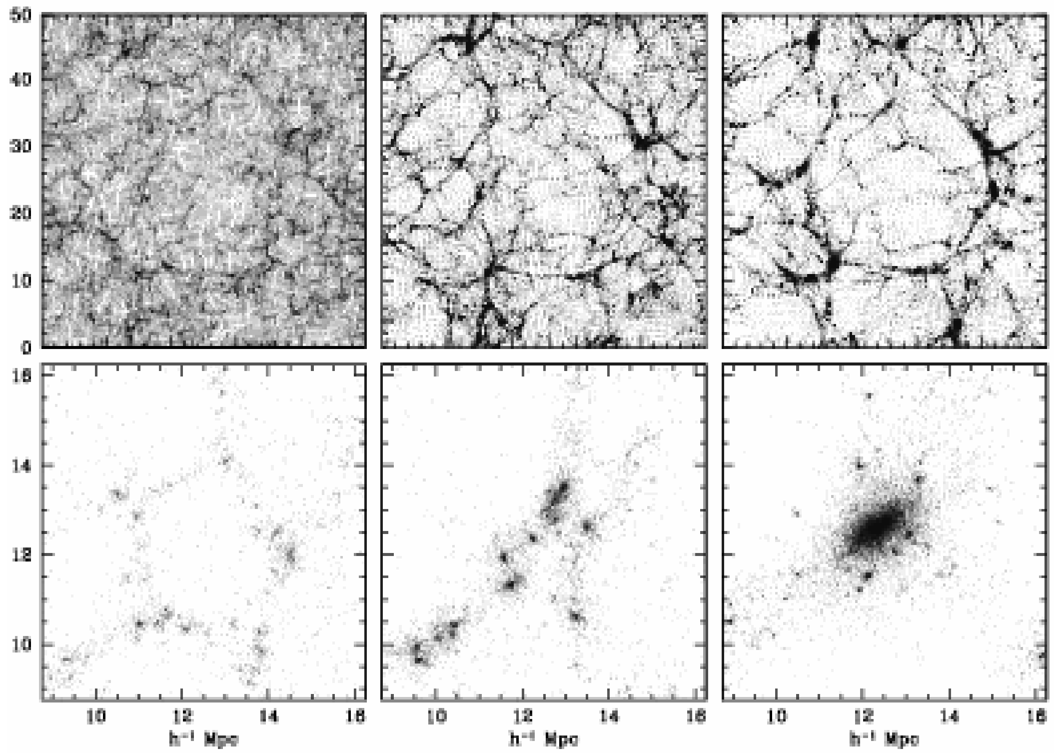


(general) Motivations

Challenge for Structures Formation Theories

Identification of 2 process :
"Void in Void" and "Void in Cloud"

R.van de Weygaert, R. Sheth
E. Platen, in IAU Coll. 195 (2004)



(our) Motivation

Challenge for Structures Formation Theories

a) Voids are non linear structures

see N. Benhamidouche, B. Torresani, R. Triay,MNRAS 302, 807 (1999)

b) « vacuum gravitational repulsion »

e.g., Schwarzschild solution of Einstein Eq. with Cosmological constant

$$\vec{g} = \left(-\mathrm{G} \frac{m}{r^3} + \frac{\Lambda}{3} \right) \vec{r}$$

c) Λ-Effect for a single void embedded in a Friedmann univers

Euler-Newton-Poisson approach

Full relativistic treatment with $\Lambda = 0$: Maeda, Sasaki & Sato, 4 PTP (1983)

Reference Coordinates

(Hubble-Friedmann Expansion)

$$(t, \quad \vec{x} = \frac{\vec{r}}{a}), \qquad a > 0$$

$$H = \frac{\dot{a}}{a} = \sqrt{\frac{\Lambda}{3} - \frac{K_\circ}{a^2} + \frac{8\pi \mathrm{G}}{3}\frac{\rho_\circ}{a^3}}$$

$$K_\circ = \frac{8\pi \mathrm{G}}{3}\rho_\circ + \frac{\Lambda}{3} - H_\circ^2 \leq \sqrt[3]{(4\pi \mathrm{G}\rho_\circ)^2\,\Lambda}, \qquad a_\circ = 1$$

$t \mapsto a$ is defined (as reciprocal mapping of a quadrature) not decreasing

$$H_m = H_\infty \sqrt{1 - \frac{K_\circ^3}{\Lambda\,(4\pi \mathrm{G}\rho_\circ)^2}}, \qquad H_\infty = \lim_{a\to\infty} H = \sqrt{\frac{\Lambda}{3}}$$

Euler-Newton-Poisson

(in the Reference Frame)

$$\frac{\partial \rho_c}{\partial t} + \mathrm{div}\,(\rho_c \vec{v}_c) = 0, \qquad \frac{\partial \vec{v}_c}{\partial t} + \frac{\partial \vec{v}_c}{\partial \vec{x}} \vec{v}_c + 2H\vec{v}_c = \vec{g}_c$$

$$\overrightarrow{\mathrm{rot}}\ \vec{g}_c = \vec{0}, \qquad \mathrm{div}\vec{g}_c = -\frac{4\pi G}{a^3}\,(\rho_c - \rho_\circ)$$

$$\rho_c = \rho a^3, \qquad \vec{v}_c = \frac{\mathrm{d}\vec{x}}{\mathrm{d}t}, \qquad \vec{g}_c = \frac{\vec{g}}{a} + \left(\frac{4\pi G}{3a^3}\rho_\circ - \frac{\Lambda}{3}\right)\vec{x}$$

Newton-Friedmann model : $\rho_c = \rho_\circ, \qquad \vec{v}_c = \vec{0}, \qquad \vec{g}_c = \vec{0}$

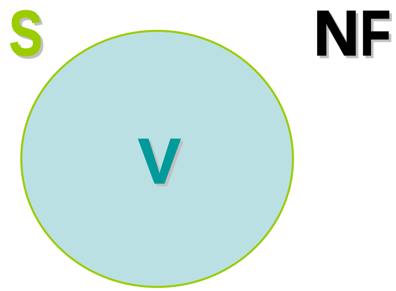
Vacuum model : $\rho_c = 0, \qquad \vec{v}_c = (H_\infty - H)\,\vec{x}, \qquad \vec{g}_c = \frac{4\pi G}{a^3}\rho_\circ \vec{x}$

Spherical Voids

$$T^{00}_{\mathrm{S}} = (\rho \mathrm{s})_c, \quad T^{0j}_{\mathrm{S}} = (\rho \mathrm{s})_c v^j_c, \quad T^{jk}_{\mathrm{S}} = (\rho \mathrm{s})_c v^j_c v^k_c$$

$$T^{00}_{\mathrm{NF}} = \rho_c, \quad T^{0j}_{\mathrm{NF}} = 0, \quad T^{jk}_{\mathrm{NF}} = 0$$

$$\vec{v}_c = \alpha \vec{x}, \qquad \vec{g}_c = \beta \vec{x}$$



Covariant formulation of Euler-Poisson eq. syst.
J.M. Souriau, (French) C.R. Acad. Sci., p.751 (1970)
C. Duval, H.P. Kunzle, Rep. Math. Phys. 13,351 (1978)

$$\frac{\mathrm{d}\alpha}{\mathrm{d}t} + 4\alpha^2 + 2H\alpha - \frac{2\pi \mathrm{G}}{3}\frac{\rho_c}{a^3} = 0$$

$$\beta = \frac{4\pi \mathrm{G}}{a^3}\left(\frac{\rho_c}{3} - \frac{(\rho \mathrm{s})_c}{2x}\right)$$

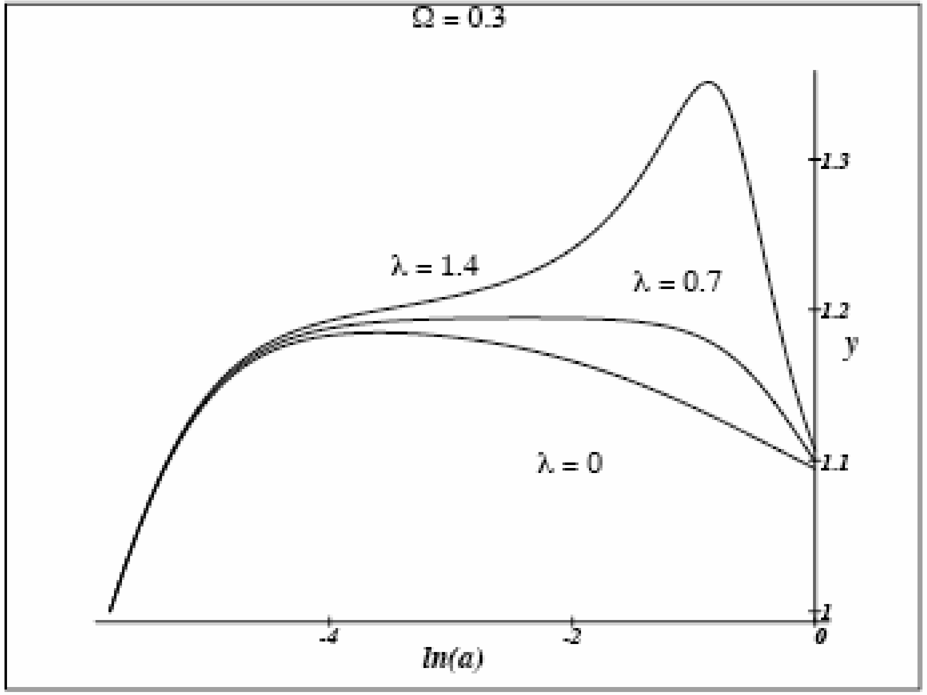
Magnification & Expansion Rate

$$x = x_i \exp\left(\int_{a_i}^{a} \frac{\chi \mathrm{d}a}{4a\sqrt{P(a)}}\right) \qquad \chi = 4\frac{\alpha}{H_\circ}a^2 \qquad P(a) = \lambda_\circ a^4 - k_\circ a^2 + \Omega_\circ a, \qquad P(1) = 1$$

$$\lambda_\circ = \frac{\Lambda}{3H_\circ^2}, \qquad \Omega_\circ = \frac{8\pi G\rho_\circ}{3H_\circ^2}, \qquad k_\circ = \frac{K_\circ}{H_\circ^2}$$

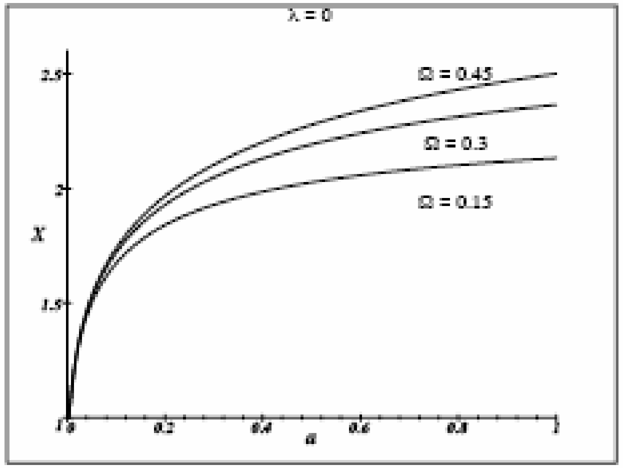
$$X = \frac{x}{x_i}, \qquad Y = \frac{\alpha}{H_\circ}$$

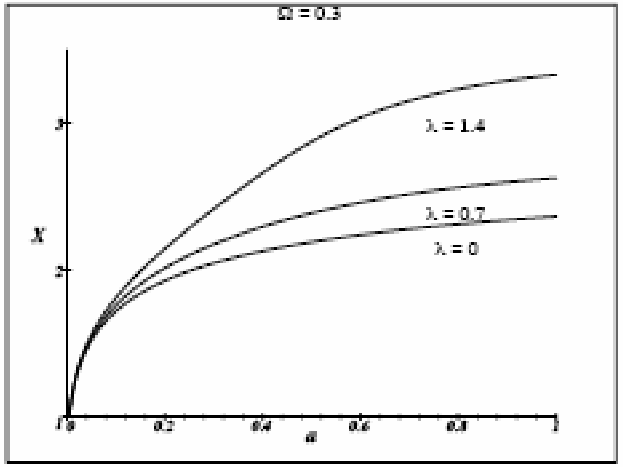
Corrective factor to Hubble expansion



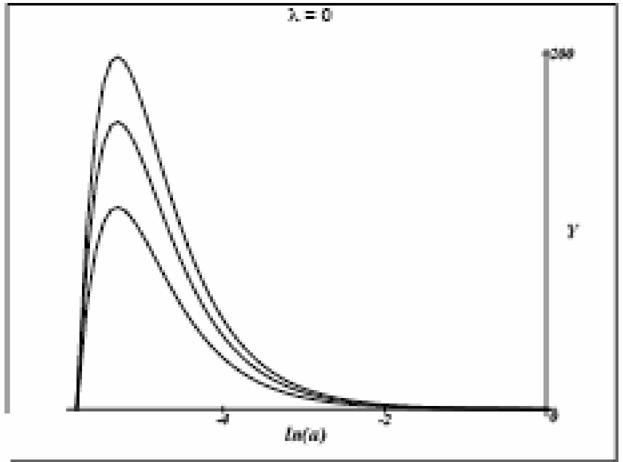
$$\vec{v} = yH\vec{r}, \qquad y = 1 + \frac{Y}{h}, \qquad h = \frac{H}{H_\circ}$$

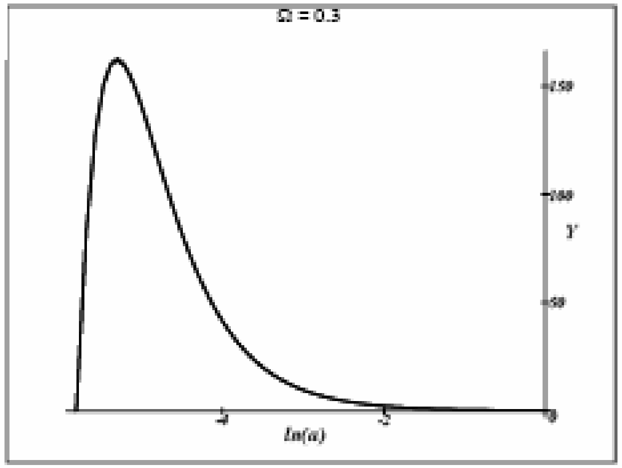
Magnification & Expansion Rate





$$\Delta z = \frac{XY}{1+z}\frac{x_i H_0}{c}$$





Formation date