Galaxies

Lecture 3

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http://wise-obs.tau.ac.il/~barkana/galaxies.html

Lecture 1: FRW metric

$$ds^2 = a^2(\tau)\left\{d\tau^2 - \left[d\chi^2 + \sin_K^2\chi\, d\Omega^2\right]\right\}$$

Friedmann equation $H^2(t) = \frac{8\pi G}{3}\rho - \frac{k}{a^2}$

$$d(\rho a^3) = -\, p d(a^3) \qquad \Rightarrow \frac{\ddot{a}}{a} = -\frac{4\pi G}{3}(\rho + 3p)$$

Light: $\triangle\tau = \triangle\chi$ $\qquad 1 + z = \frac{\lambda(a_0{=}1)}{\lambda(a)} = \frac{1}{a}$

Mat. Dom.: $a \propto t^{2/3}$ $\qquad$ Rad. Dom.: $a \propto t^{1/2}$

Momentum redshift: $q \propto \frac{1}{a}$

Planck Dist.: $T \propto \frac{1}{a}$

Lecture 2: 2-point correlation function

$$\xi(r_{12}) = \left\langle \delta(\vec{x}_1)\delta(\vec{x}_2) \right\rangle \quad r_{12} = \left| \vec{x}_1 - \vec{x}_2 \right|, \ \left\langle \delta(\vec{x}) \right\rangle = 0$$

Discrete, Poisson noise:

$$\left\langle \delta(\vec{x}_1)\delta(\vec{x}_2) \right\rangle^d = \xi(r_{12}) + \bar{n}^{-1}\delta^D(\vec{x}_1 - \vec{x}_2)$$

Power Spectrum: $\left\langle \hat{\delta}(\vec{k}_1)\hat{\delta}(\vec{k}_2) \right\rangle \equiv P(k_1)\delta^{\mathrm{D}}(\vec{k}_1 + \vec{k}_2)$

$$\xi(r) = \int d^3k \, e^{i\vec{k}\cdot\vec{x}} P(k) \, = 4\pi \int_0^\infty k^2 dk \, P(k) \, \frac{\sin(kr)}{kr}$$

$$\sigma_R^2 = \bar{\xi}(0) = 4\pi \int_0^\infty k^2 dk P(k) \tilde{W}^2(kR)$$

Gaussian Random Field: $\left\langle \delta_2 | \delta_1 \right\rangle = \delta_1 \frac{\xi(r)}{\xi(0)}$

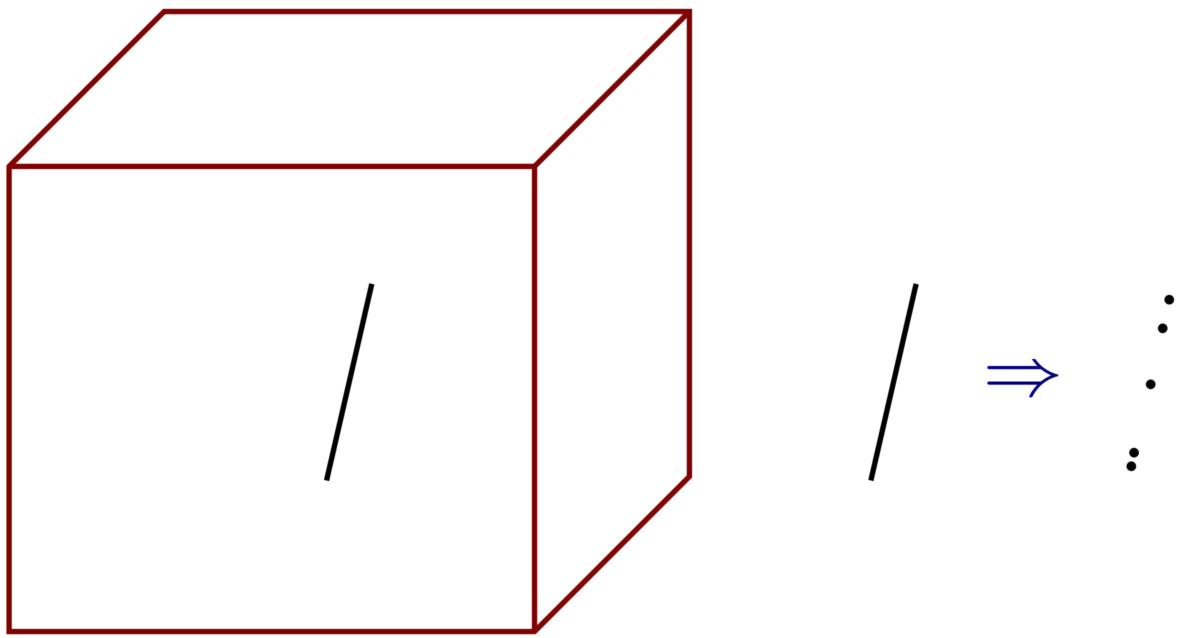
Statistics: Example

Discrete (Point Process)   2-point correlation function

$$dP(\vec{x}_1, \vec{x}_2) = \bar{n}^2 d^3x_1 d^3x_2 [1 + \xi(r_{12})]$$

$$dP(r|0) = \bar{n}[1 + \xi(r)]dV$$

Cox Process



Statistics: Example

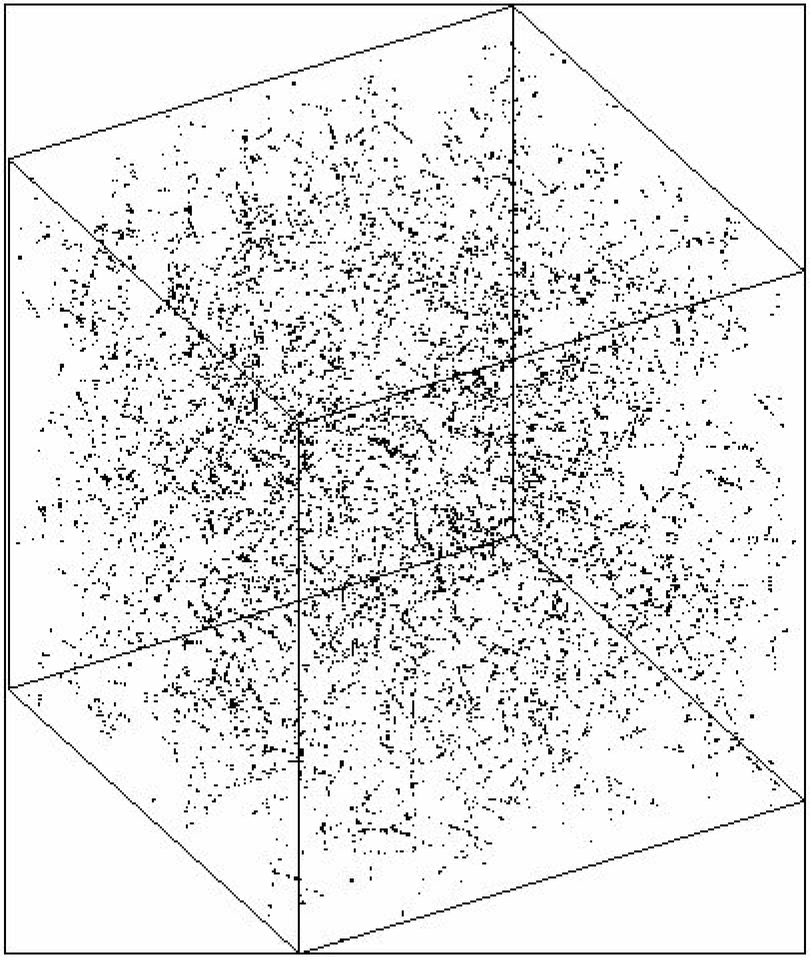
Cox Process

$$\xi_{Cox}^{r \leq L}(r) = \frac{1}{2\pi n_S}\left(\frac{1}{r^2 L} - \frac{1}{r L^2}\right)$$

$L = 10$

$V = 100^3$

$\langle N_S \rangle = 1000$



Martinez & Saar 2002

http://nedwww.ipac.caltech.edu/level5/Sept02/Martinez/Martinez_contents.html

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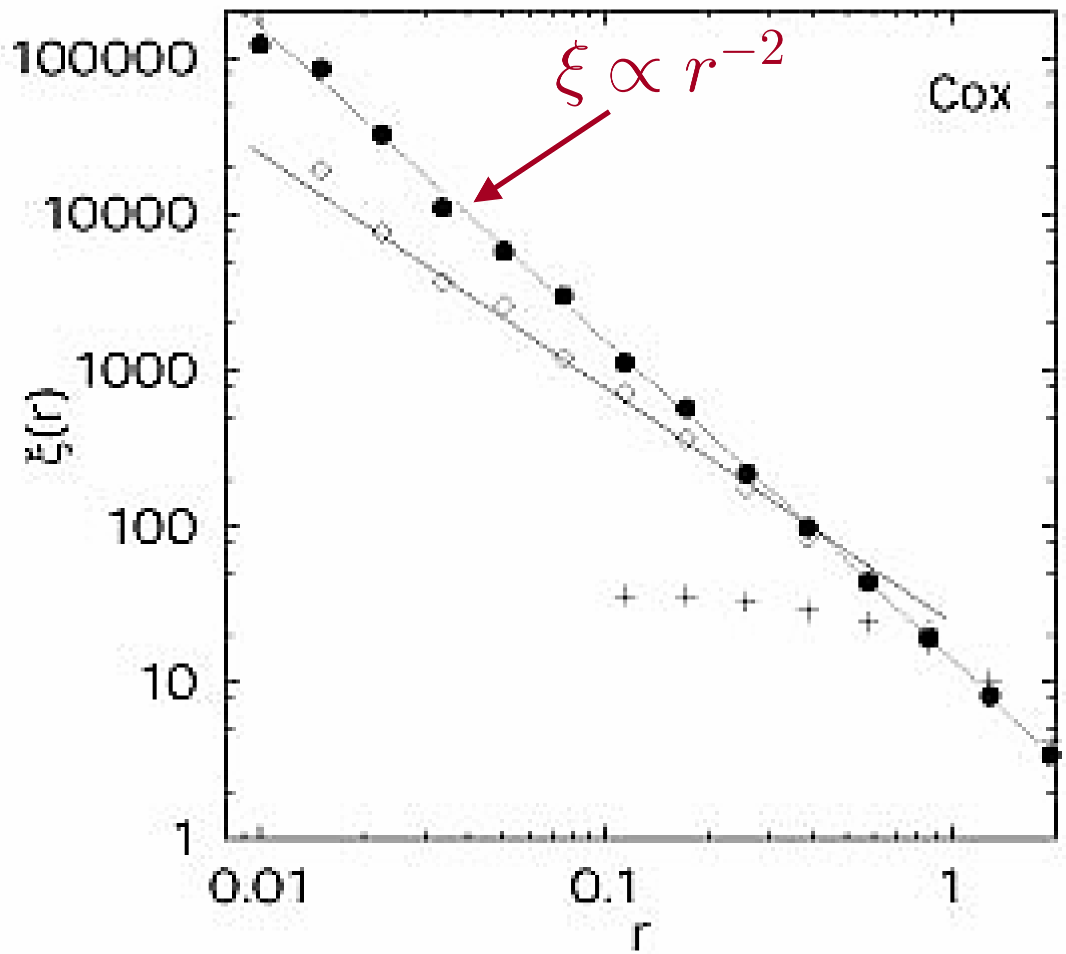

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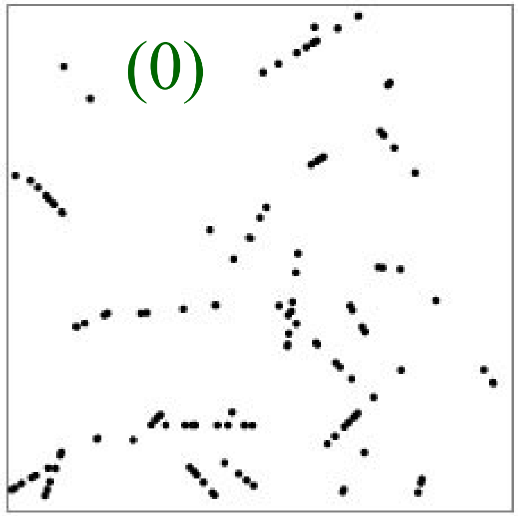
Statistics: Example

(0) Cox Process

Slice:
$40 \times 40 \times 10$



Smoothing:

$\bullet\xrightarrow{d}\bullet$

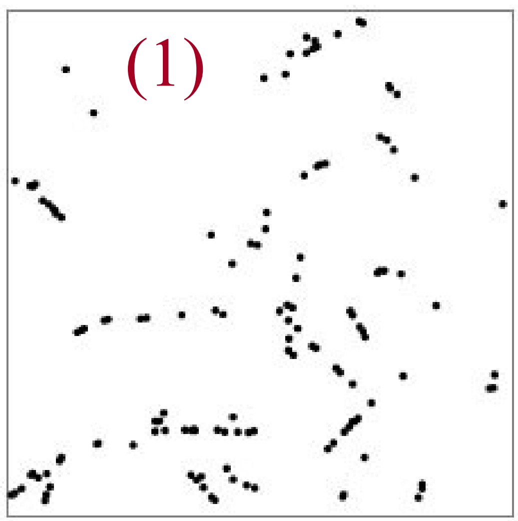
(1) $p(d) \propto d^{-0.75}$

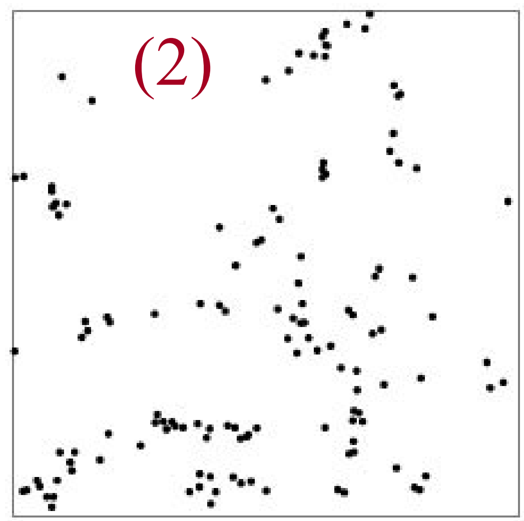
(2) Normal $(\sigma = 0.5)$

$L = 10$

$V = 100^3$

$\langle N_S \rangle = 1000$





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Statistics: Example

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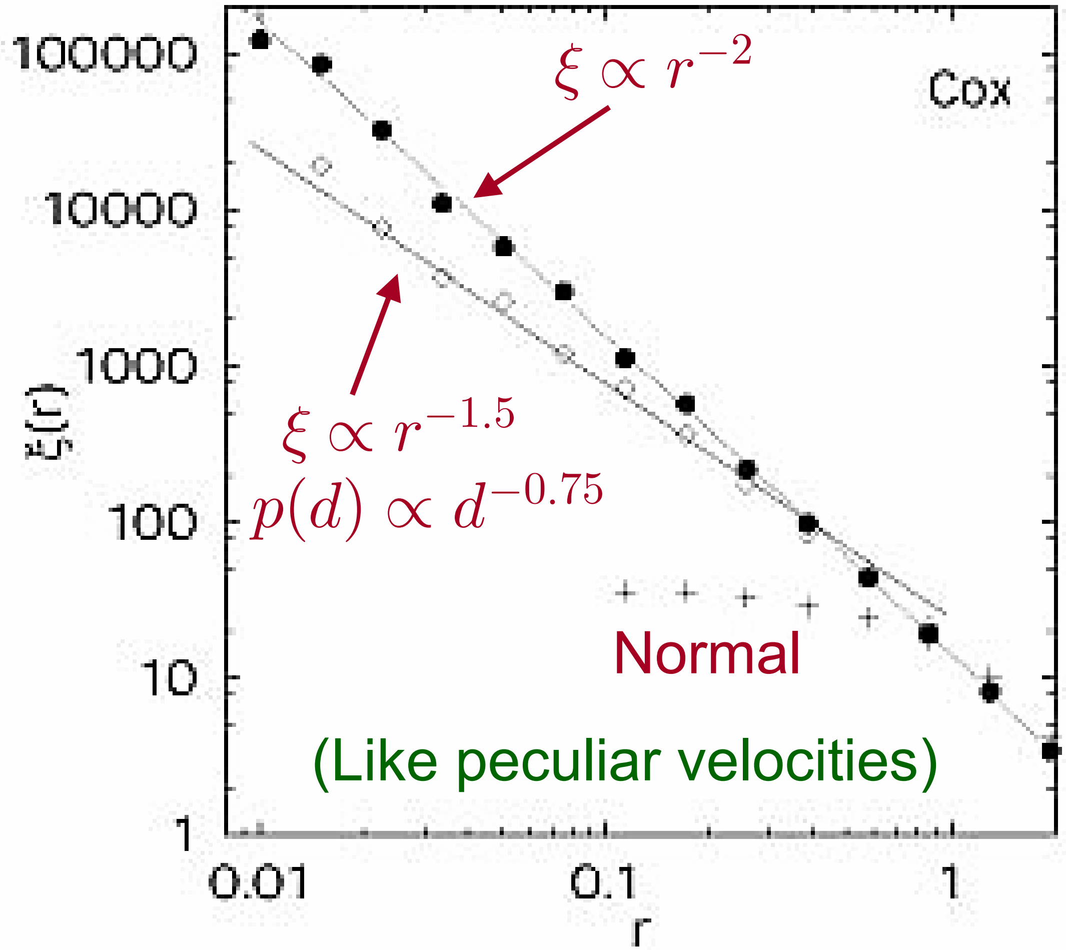

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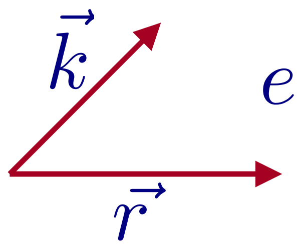
Statistics: P.S.

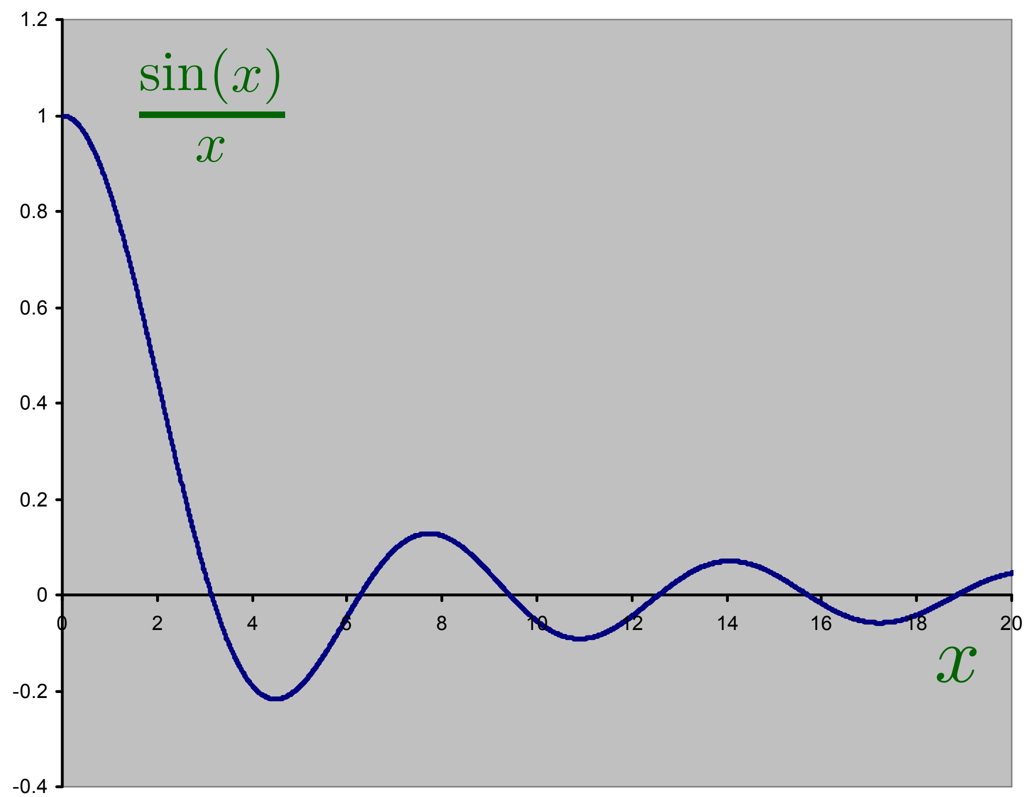
$$\xi(r) = 4\pi \int_0^\infty k^2 dk P(k) \frac{\sin(kr)}{kr}$$



$$e^{i\vec{k}\cdot\vec{r}}$$

$$kr \ll 1 :$$

Two points at distance r are on the same part of the wave.



Statistics: P.S.

$$\bar{\xi}(0) = 4\pi \int_0^\infty k^2 dk P(k) \tilde{W}^2(kR)$$