

Master Thesis

Statistical Properties of Particle Spreading in
Quenched Random Media

Shiraz University

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September 2019

Motivation

Anomalous is Normal

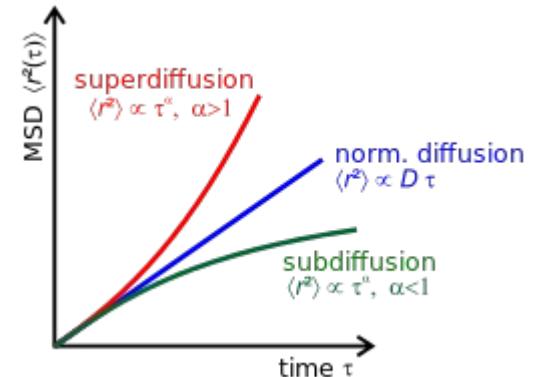
Klafter and I. M. Sokolov, Anomalous diffusion spreads its wings, Physics world, vol. 18, no. 8, p. 29, 2005

CTRW

fBm

Levy flight

$$\langle x^2 \rangle \sim t^\alpha$$



Disordered Media Shows Anomaly

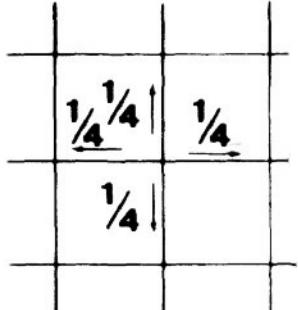
Porous Media

Cell Environment

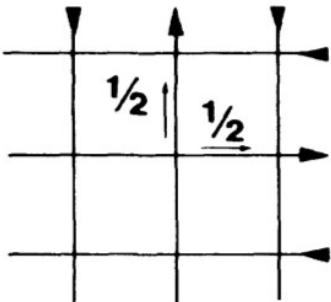
Complex Networks

...

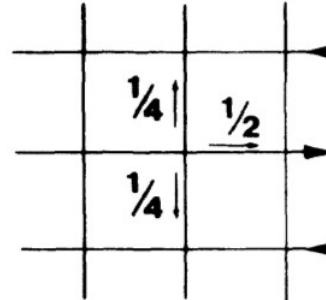
Manhattan Grid



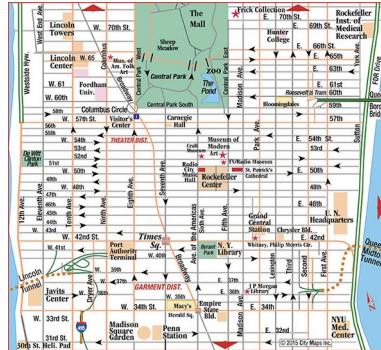
$$\alpha = 1$$



$$\alpha = 4/3$$



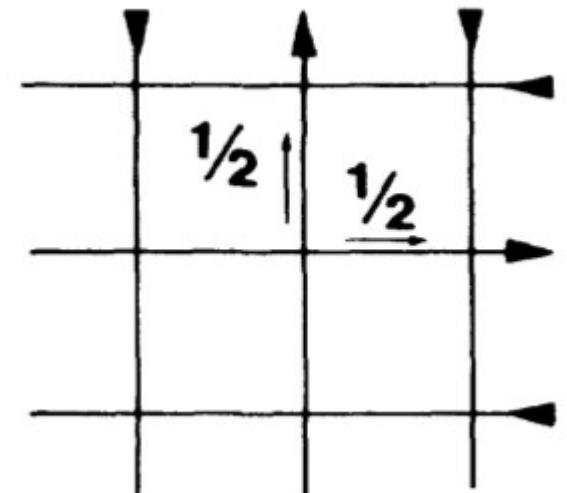
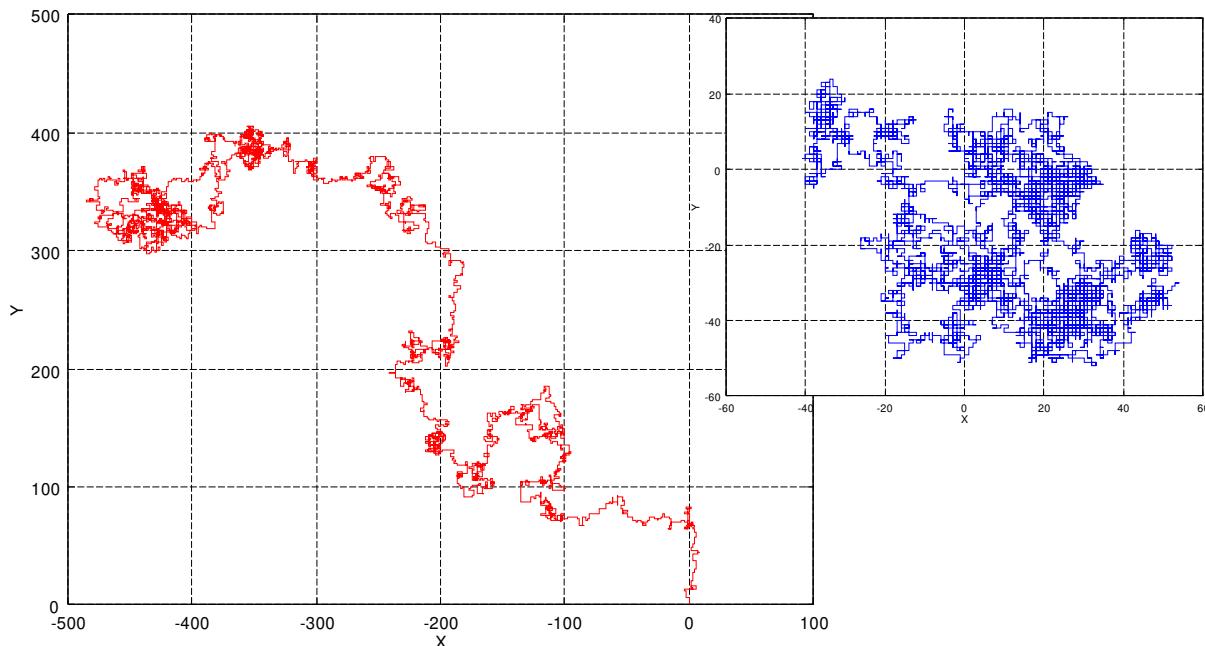
$$\alpha = 3/2$$



Diffusion in Quenched Manhattan Grid

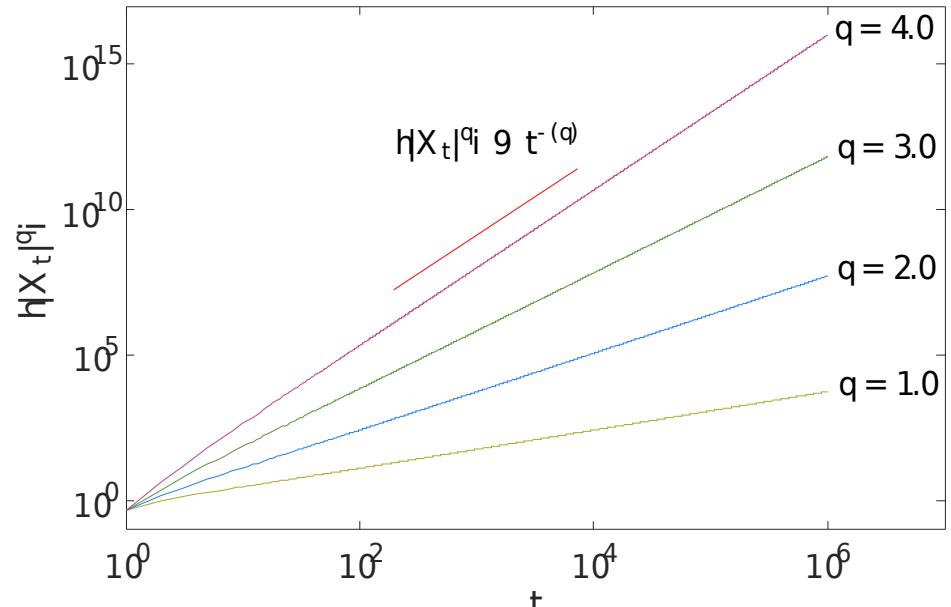
$$x(t + \Delta t) = x(t) + \eta(t)\mathcal{U}(y(t))\Delta t$$

$$y(t + \Delta t) = y(t) + [1 - \eta(t)]\mathcal{V}(x(t))\Delta t$$

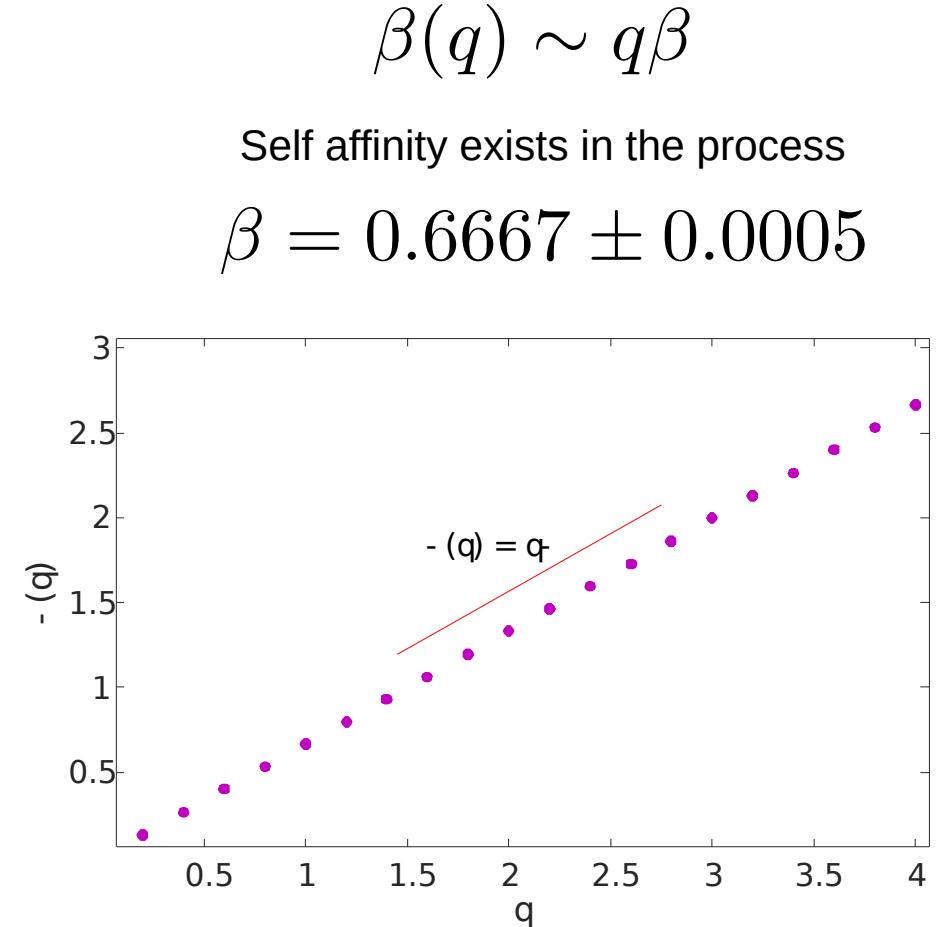


The motion is
Super-diffusive with
 $\alpha = 1.33 \pm 0.01$

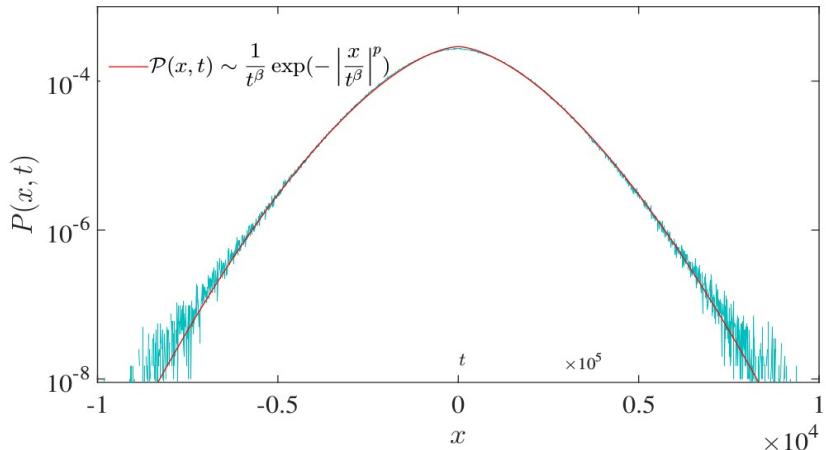
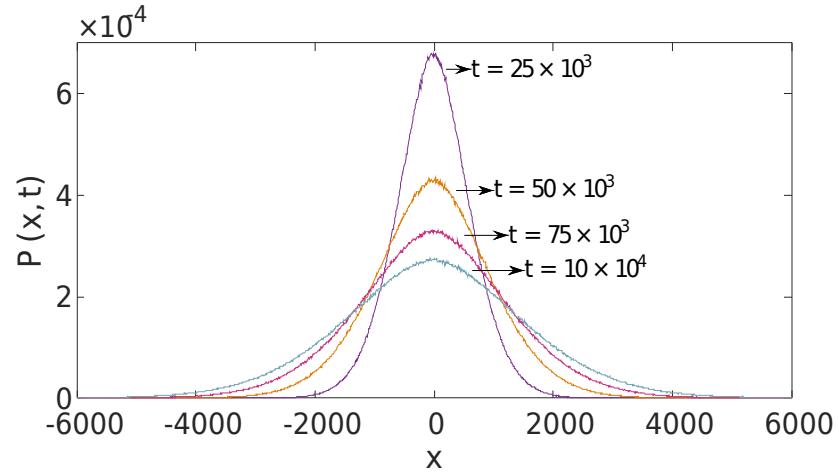
Moments of Diffusion



$$\langle |x|^q \rangle \sim t^{\beta(q)}$$



Gaussian or Non-Gaussian



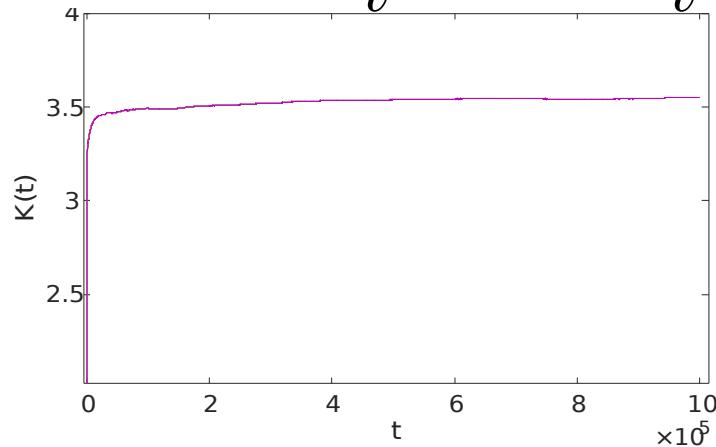
We expect $\mathcal{P}(x,t) \sim \frac{1}{t^\beta} \mathcal{F}\left(\frac{x}{t^\beta}\right)$

$$\mathcal{K} = \frac{\langle |x(t)|^4 \rangle}{\langle |x(t)|^2 \rangle^2} = 3.54 \pm 0.01$$

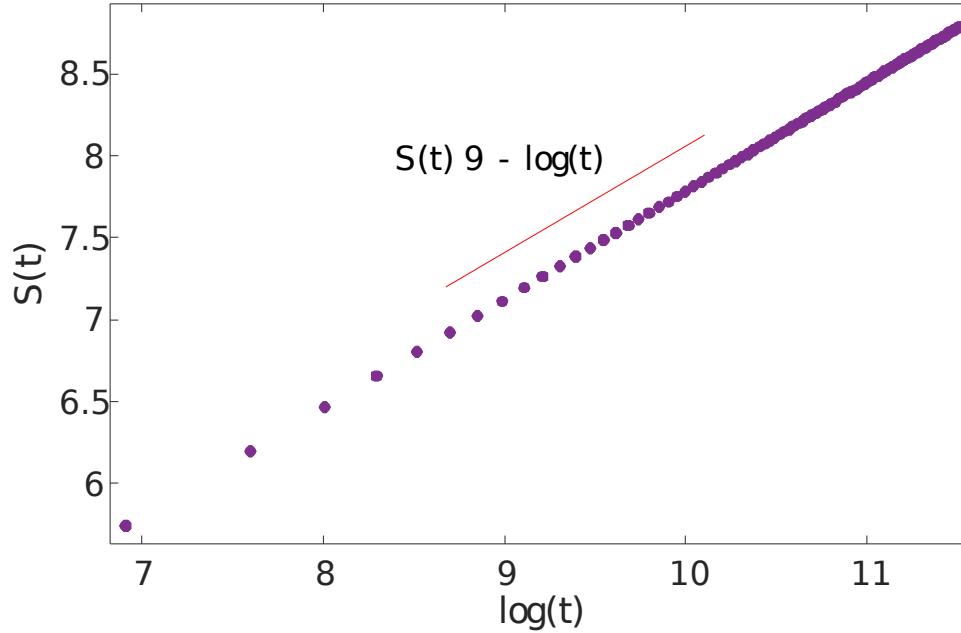
we choose GGD: $\mathcal{F}(u) \propto \exp(-|u|^p)$

$$\mathcal{K} = \frac{\Gamma(5/p)\Gamma(1/p)}{\Gamma^2(3/p)} \implies p = 1.607 \pm 0.006$$

$$\mathcal{P}(x,t) \sim \frac{1}{t^\beta} \exp\left(-\left|\frac{1}{t^\beta}\right|^p\right)$$



DEA

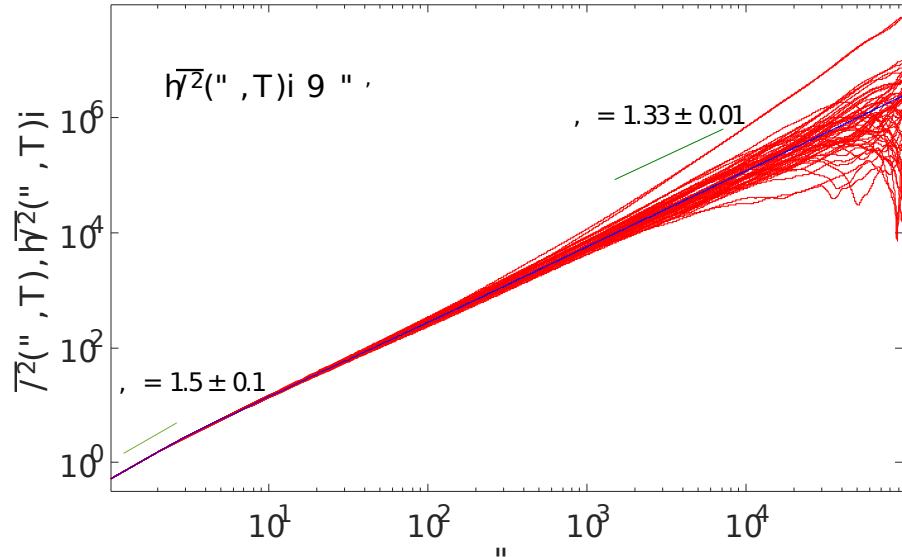


$$S(t) = - \int \mathcal{P}(\vec{r}, t) \log \mathcal{P}(\vec{r}, t) d\vec{r}$$

$$S(t) = \beta \log t - \int \mathcal{F}(u) \log \mathcal{F}(u) du = \beta \log t + cns.$$

$$\beta = 0.6629 \pm 0.0001$$

Weak Ergodicity Breaking and Aging



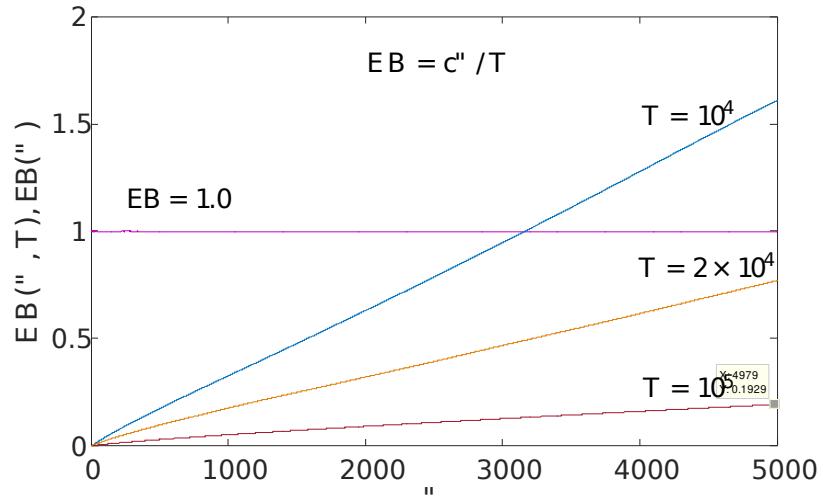
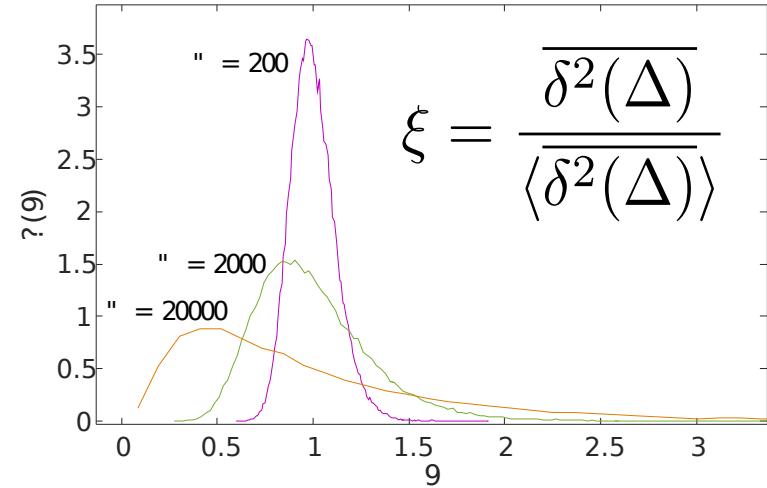
$$\overline{\delta^2(\Delta, T)} = \frac{1}{t - \Delta} \int_0^{T - \Delta} [\vec{r}(t + \Delta) - \vec{r}(t)]^2 dt$$

$$\lim_{T \rightarrow \infty} \overline{\delta^2(\Delta, T)} = \langle \vec{r}^2(\Delta) \rangle$$

$$\langle \overline{\delta^2(\Delta, T)} \rangle = \frac{1}{N} \sum_{i=1}^N \overline{\delta^2(\Delta, T)}$$

$$EB(\Delta) = \lim_{T/\Delta \rightarrow \infty} \langle \xi^2 \rangle - 1$$

$$\mathcal{EB} = \frac{\langle \overline{\delta^2(\Delta)} \rangle}{\langle \vec{r}^2(\Delta) \rangle}$$



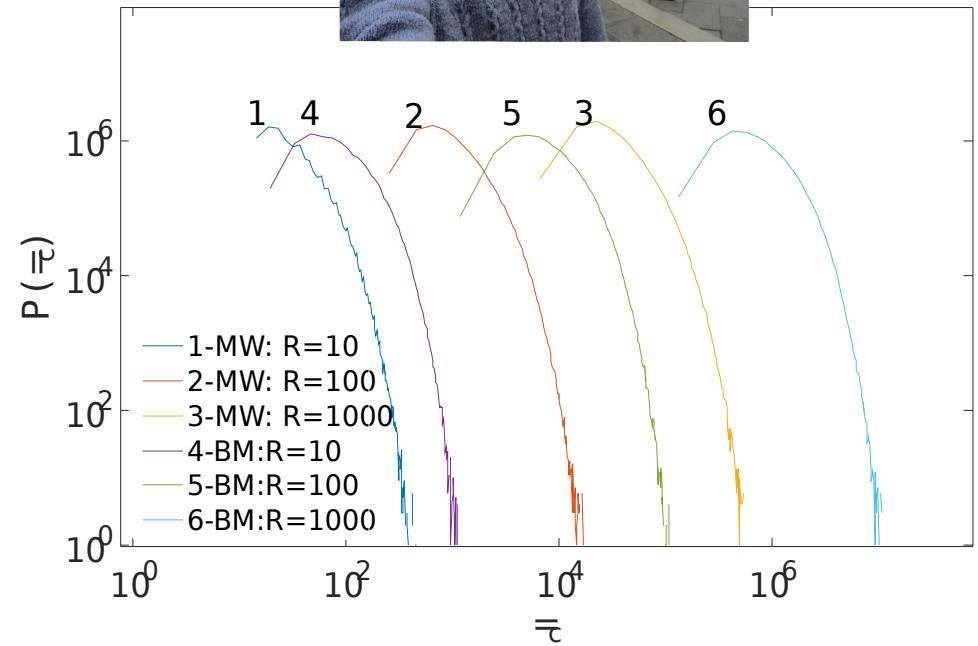
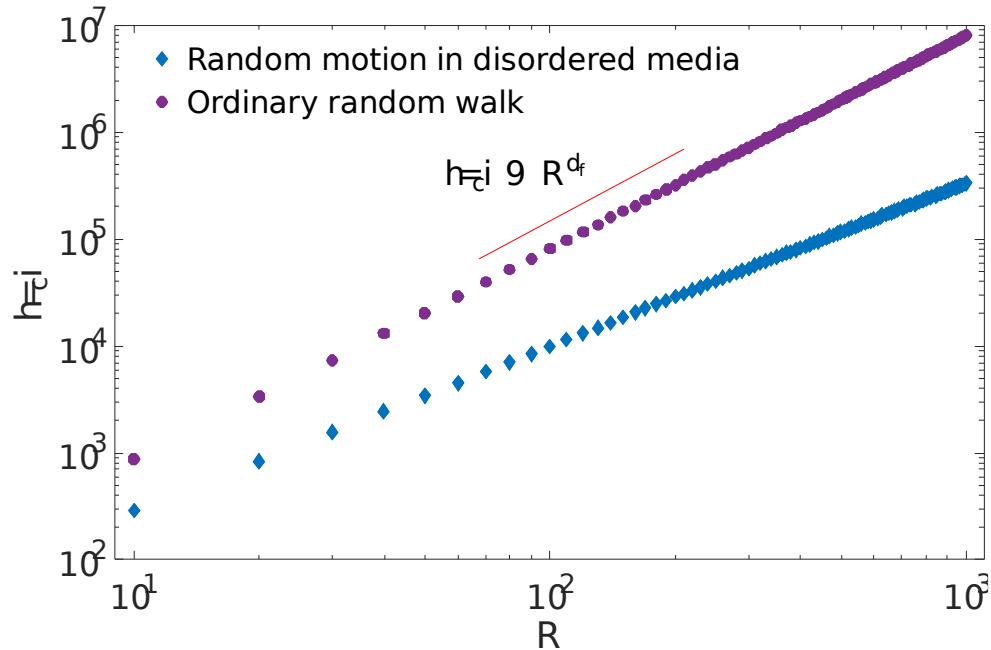
First Exit Time

$$\tau_c = \inf\{t > 0 : |\vec{r}(t)| \geq R\}$$

$$\langle \tau_c \rangle \sim R^{d_f}$$

$$d_f = 1.522 \pm 0.005$$

$$d_f = 1.998 \pm 0.005$$

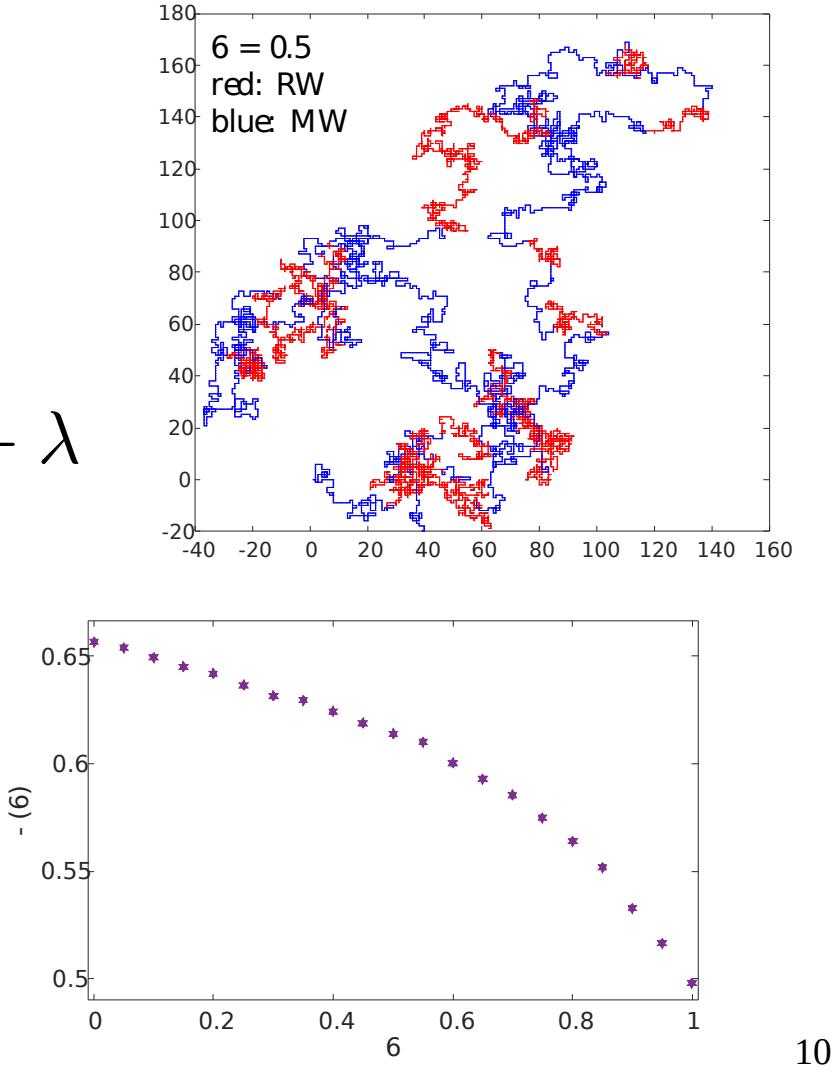
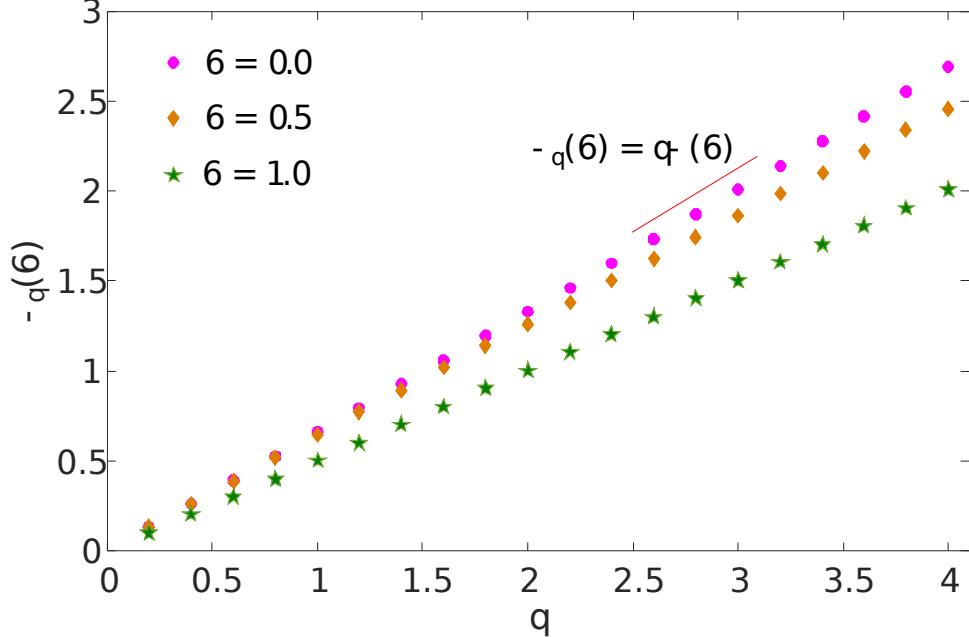


Random Dance

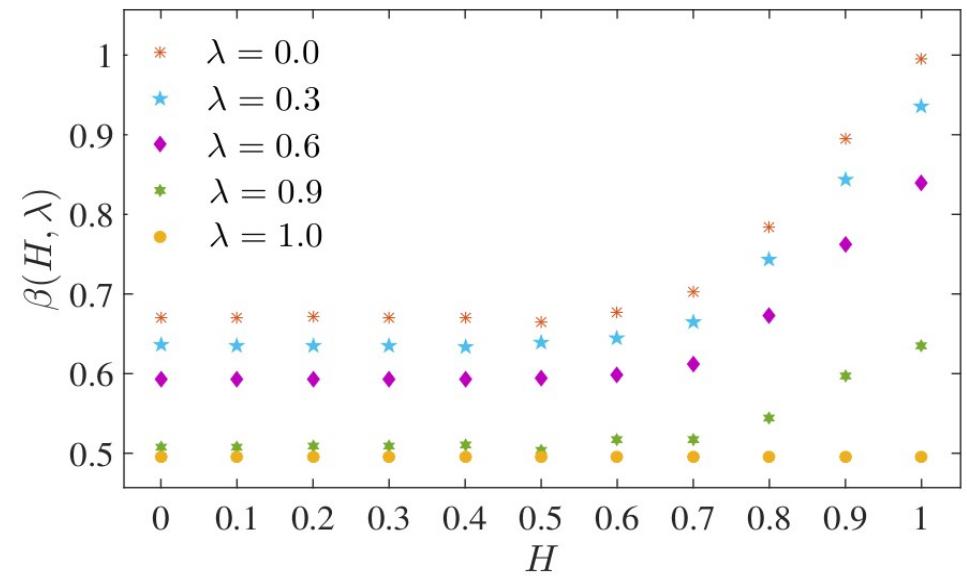
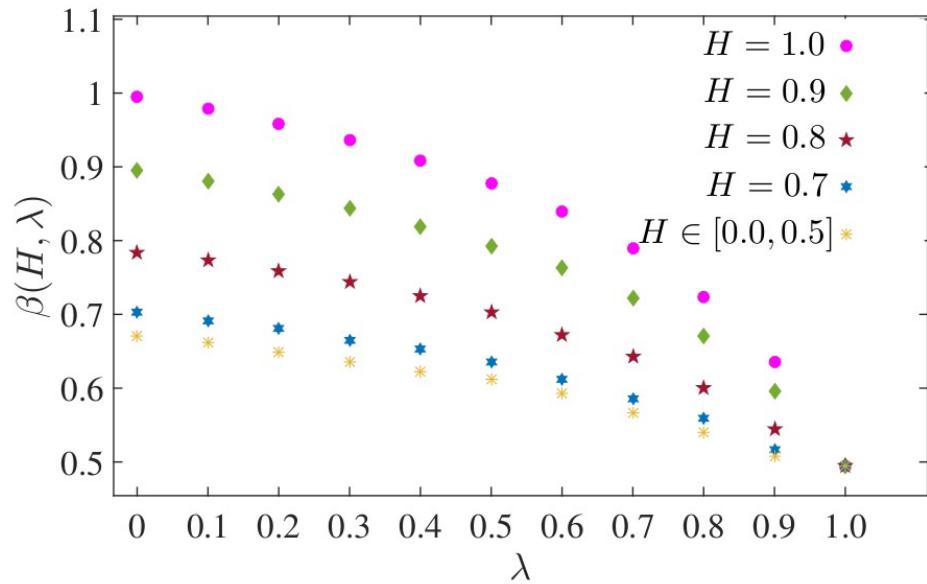
$$x(t + \Delta t) = x(t) + \left[\phi(\tau_n) \xi(t) + (1 - \phi(\tau_n)) \{ \eta(t) \mathcal{U}(y(t)) \} \right] \Delta t$$

$$y(t + \Delta t) = y(t) + \left[\phi(\tau_n) \xi(t) + (1 - \phi(\tau_n)) \{ (1 - \eta(t)) \mathcal{V}(x(t)) \} \right] \Delta t$$

$$\sum_n \tau_n = T \quad P(\phi(\tau_n) = 1) = \lambda \quad P(\phi(\tau_n) = 0) = 1 - \lambda$$



Correlation Effect

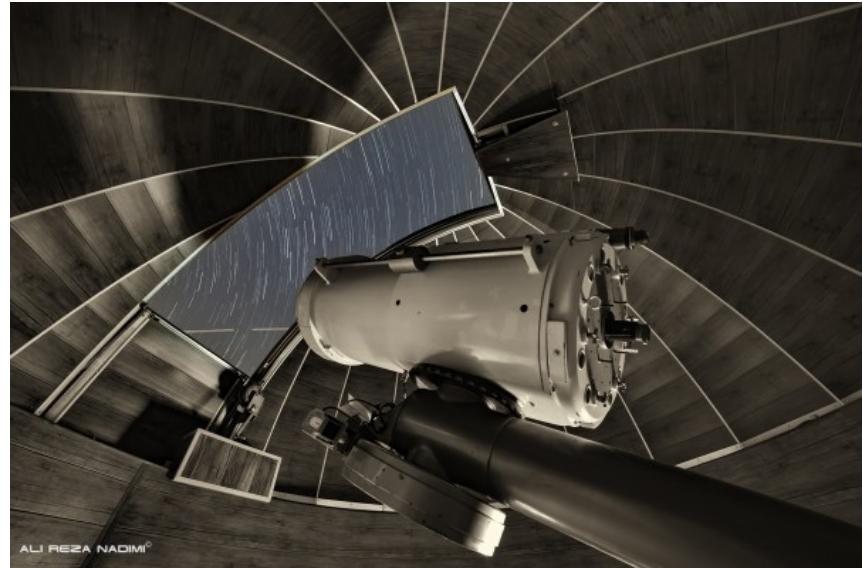
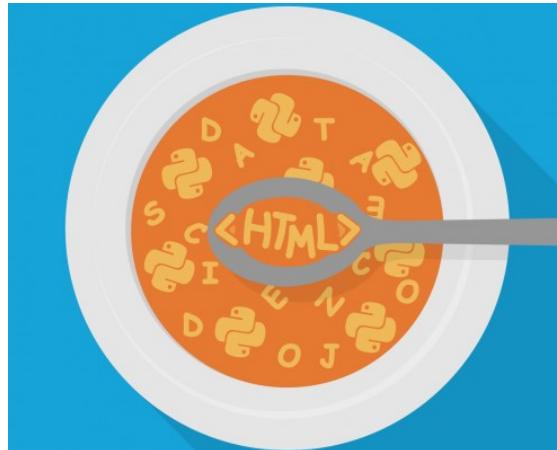


$$\langle \mathcal{U}_x[y_1] \mathcal{U}_x[y_2] \rangle = \sigma^2 [H(2H-1)] |y_1 - y_2|^{2H-2}$$

$$\langle \mathcal{U}_y[x_1] \mathcal{U}_y[x_2] \rangle = \sigma^2 [H(2H-1)] |x_1 - x_2|^{2H-2}$$

Previous Projects

- Synchronization
- Variable Star Photometry
- Internship as Data Scientist





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Denny Hamlin

A star-class article from Wikipedia, the free encyclopedia

This biographical article needs additional citations for verification. Please help by adding reliable sources. Contentious material about living persons that is unsourced or poorly sourced must be removed immediately, especially if potentially libelous or harmful. (August 2012)

James Dennis Alan "Denny" Hamlin (born November 18, 1980)^[1] is an American NASCAR race car driver. He currently drives the No. 11 FedEx Toyota in the Nationwide Series. Hamlin was born in Tampa, Florida, but lived in Chesapeake, Virginia for most of his childhood. He began racing go-karts at the age of 7. Afterward, he worked his way up to Late Model racing in the Sprint Cup Series and the Toyota in the Nationwide Series.

Denny Hamlin

Hamlin's career highlights include winning the 2011 Daytona 500, the 2012 Brickyard 400, and the 2013 Coca-Cola 600. He has also won multiple races in the Xfinity Series and Camping World Truck Series. In addition to his racing career, Hamlin is involved in various charitable causes, including the Denny Hamlin Foundation and the Denny Hamlin Family Foundation.

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DNA

From Wikipedia, the free encyclopedia

For a non-technical introduction to the topic, see *Introduction to genetics*.
For other uses, see *DNA* (disambiguation).

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Croup, also known as *laryngotracheobronchitis*, is a type of respiratory infection that is usually caused by a virus.^[1] The infection leads to swelling inside the trachea, which interferes with normal breathing and produces the classic symptoms of "barking" cough, stridor, and a hoarse voice.^[1] Fever and runny nose may also be present.^[1] These symptoms may be mild, moderate, or severe.^[2] Often it starts or is worse at night.^{[1][2]} It normally lasts one to two days.^[3] Croup can be caused by a number of viruses including parainfluenza and influenza virus.^[1] Rarely it is due to a bacterial infection.^[4] Croup is typically diagnosed based on signs and symptoms after potentially more severe causes, such as epiglottitis or an airway foreign body, have been ruled out.^[5] Further investigations—such as blood tests, X-rays, and cultures—are usually not needed.^[6] Many cases of croup are preventable by immunization for influenza and diphtheria.^[4] Croup is usually treated with a single dose of steroids by mouth.^[1] In more severe cases inhaled epinephrine may also be used.^{[1][6]} Hospitalization is required in one to five percent of cases.^[7] Croup is a relatively common condition that affects about 15% of children at some point.^[8] It most commonly occurs between 6 months and 5 years of age but may rarely be seen in children as old as fifteen.^{[2][9][7]} It is slightly more common in males than females.^[7] It occurs most often in autumn.^[7] Before vaccination, croup was frequently caused by diphtheria and was often fatal.^{[4][9]} This cause has now very rare in the Western world due to the success of the diphtheria vaccine.^[6]

Signs and symptoms

Croup is characterized by a "barking" cough, stridor, hoarseness, and difficulty breathing which usually worsens at night.^[1] The "barking" cough is often described as resembling the call of a seal or sea lion.^[4] The stridor is worsened by agitation or crying, and if it can be heard at rest, it may indicate critical narrowing of the airways. As croup worsens, stridor may decrease considerably.^[1] Other symptoms include fever, coryza (symptoms typical of the common cold), and indrawing of the chest wall—known as Hoover's sign.^{[1][10]} Drooling or a very sick appearance indicate other medical conditions, such as epiglottitis.^[10]

The steeple sign as seen on an AP neck X-ray of a child with croup

Symptoms Laryngotracheitis, subglottic laryngitis, obstructive laryngitis, laryngotracheobronchitis

Specialty Pediatrics

Symptoms "Barking" cough, stridor, fever, stuffy nose^[1]

Duration Usually 1-2 days but can last up to 7 days^[2]

Causes Mostly viral^[1]

Current Project

