Code Applications and Data

Lecture 3

2/9/17

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fBmMLE.m: input

- First input is an Nx2 matrix of x and y positions
- Second input is dt (aka the shortest lag time)
- Third input is dt
  - This is an easy way for the code to assume a linear drift

fBmMLE.m: output

- [mle, ci]
- “mle.Sigma” is a 2x2 matrix. To transform to D, do: (Sigma(1,1) + Sigma(2,2))/4
  - Sigma here is actually sigma squared, where D = .5*sigma^2
- “mle.Beta” are the drift parameters in each coordinate
- “mle.alpha” is alpha

“other analytics”

- brownianMLE.m – finds MLE of D and drift params, mu, for brownian paths
- path_MSD.m – computes MSD for a single path at optimal lag times
- fBmXY_HD.m – simulates fBm paths (can be used to simulate brownian paths as well)
- ellipse.m – calculates confidence ellipses (for (D,α) distributions) using principal components
- dimless.m – non-dimensionalizes D
- Moduli.m – tranforms MSD into the viscous and elastic moduli by the generalized Stokes-Einstein relation (Mason-Weitz 1996)
  - spline_der.m – used for spline interpolation of the MSD in Moduli.m

path_MSD.m

- [msd, lags] = path_MSD(data, frame_rate)
- To plot: plot(lags, msd)
  - set(gca, ‘xscale’, ‘log’); set(gca, ‘yscale’, ‘log’)

ellipse.m

- To plot the output: plot(exp(e(1,:)), e(2,:)), since the ellipse is fitting data that has a semi-log scaling

dimless.m

- Outputs a non-dimensionalized value for D (no units, like alpha), and requires as input: alpha, dimensional D (from mle fit) and bead diameter, which will be 1 for our experiments

Moduli.m: input

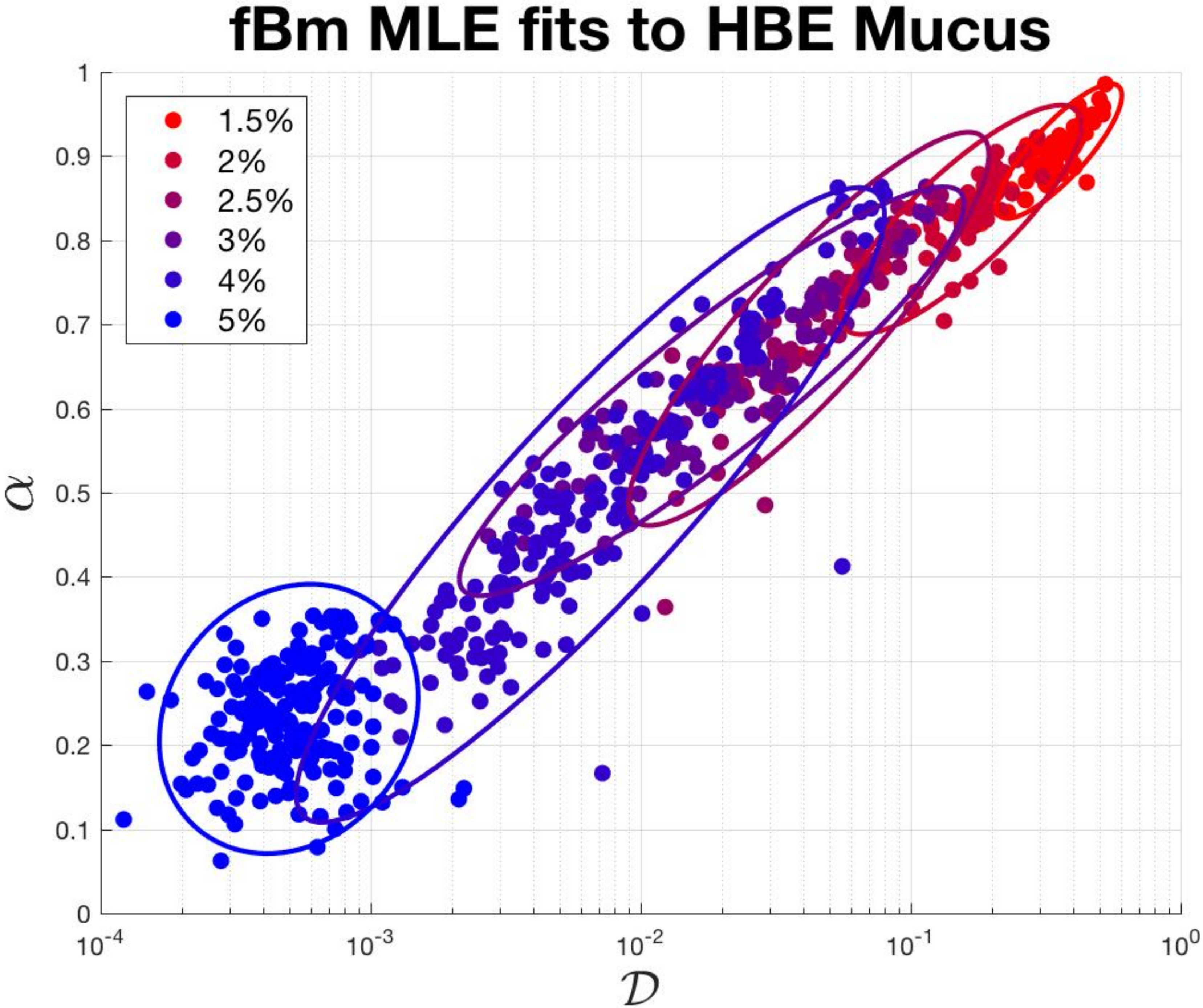
- First argument is a 2xM matrix of MSD (top row) and the corresponding lag times (second row)
- Second argument is the number of points used in the spline interpolation (use 200)

Moduli.m: output

- First is G’ (elastic modulus)
- Second is G” (viscous modulus)
- Third is omega (frequency)
- When plotting, we need to convert omega to radians, so transform the frequency to -> 2*pi*omega

The Dataset

- HBE mucus: Several different weight percents of cell culture mucus (the same used in the PLoS ONE paper). Mucus is heterogeneous.
  - Frame rate = 60 fps
  - Bead diameter = 1 micron
  - Try to recreate the following figure:



fBm MLE fits to HBE Mucus
1.5%
2%
2.5%
3%
4%
5%
α
𝒟
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10^-4
10^-3
10^-2
10^-1
10^0

Papers

- How MLE works: JOR Mellnik et al 2016
  - https://arxiv.org/pdf/1509.03261.pdf
- PLoS ONE HBE mucus: PLoS ONE Feb 2014 Hill et all
  - http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0087681