DLS Minicourse Informal Final Exam (Lab final, Fall Semester 2010).

This exam is designed to see how effective our near-peer teaching approach to DLS training has been. If gaps are identified in your knowledge, we will fill them and try to arrive at a better training regimen. You must work independently. If there is a question, you can ask ME but no one else. If your question reveals an ambiguity or error in one of the questions, I will circulate the answer to the others.

You can use whatever books, articles and websites you want.

The accompanying Excel file contains a single x-y dataset. It is simulated in the form of a homodyne ALV correlator file. The x-coordinate is for lag time. The y-coordinate represents a correlation function. Random noise has been added.

You can write your answers using a pencil or using Word, in the latter case, please use a BLUE font.

WORK THE PROBLEMS IN THE ORDER ASSIGNED. IF YOU CANNOT DO A PROBLEM, MOVE ON TO THE NEXT ONE AND DO NOT RETURN!!!! YOU ARE ON YOUR HONOR TO WORK PROGRESSIVELY THROUGH THE EXAM.

1. Plot the correlation function in the usual linear-y/log-x scale displayed on the correlator itself.
a) How many exponential decays do you see?
b) Estimate each decay rate(s) *by eye (say how you did it).*

2. Replot the correlation function in the log-y/linear-x scale the correlator is *supposed* to always be displayed (old ALV) and can be *requested* to display (new ALV).

a) How many exponential decays do you see?

b) Estimate each decay rate(s) *by eye (say how you did it).*

3. Prove mathematically that the first cumulant of a first-order, multiexponential correlation function is the average decay rate over the distribution.

4. About how much noise (by percent) is present on this correlation function? (Hint: noise is unrealistically simulated in this case to be some percent of the baseline).

5. Why is simulating the noise in this way unrealistic?

6. Use an error-weighted fit in Origin (or similar) to determine the first cumulant from a third-order cumulant fit. Make a residuals plot and use the appropriate number of channels to keep it random. Report as follows:
a. the first cumulant
b. estimated uncertainty from Origin
c. uncertainty estimated from realistic variation of the channels used.
d. which is larger, b or c?

7. What baseline did you use in your cumulant fit? How can you adjust the baseline in a cumulant fit if you need to?

8. Devise a Solver solution to identify the decay rates and associated amplitudes. Do it by fitting the $g^{(1)}$ function obtained from $g^{(2)}$ using the Siegert relation and a baseline you select. (MATLAB or Mathematica Solve solutions also OK). Report the following:

a. A1, A2, A3, etc….. (amplitudes)

b. Gamma1, Gamma2, Gamma3, etc…. (decay rates)

c. Baseline.

9. Guided by your results so far, repeat the Solver solution, but this time fit $g^{(2)}$ directly and include a floating baseline. Report the following:
a. your strategy.
b. A1, A2, A3, etc….. (amplitudes)
c. Gamma1, Gamma2, Gamma3, etc…. (decay rates)
d. Baseline.

10. In two parts:

a. Convert the Gamma1, Gamma2, Gamma3, etc. results to particle R_h values, assuming: viscosity = 0.01002, T=20^{o}C, laser wavelength = 6328 Angstroms, scattering angle = 90 degrees, refractive index = 1.33.

b. Extract the most information possible from the amplitude results, assuming the particles are spherical and share the same chemical properties.

11. Based on criteria expressed in our papers, is this sample a candidate for analysis by one of the Laplace inversion algorithms, such as CONTIN?

12. If the correlation function represented a well-performed heterodyne run, how would its appearance differ from what you plotted in Question #1?

13. Sometimes people say DLS and SLS each return a z-average size. In fact, SLS returns the square root of the z-average of the square of R_g while DLS returns the inverse of the z-average of the inverse of R_h. Write expressions for these two "z-averages" using standard N_i, M_i, $R_{g,i}$ and $R_{h,i}$ notation.