tweezercalib 2.1: Faster version of MatLab package for precise calibration of optical tweezers ★

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New version program summary

Title of program: tweezercalib
Catalogue identifier: ADTV_v2_1
Program summary URL: http://cpc.cs.qub.ac.uk/summaries/ADTV_v2_1
Program obtainable from: CPC Program Library, Queen’s University of Belfast, N. Ireland
Licensing provisions: no
No. of lines in distributed program, including test data, etc.: 134 188
No. of bytes in distributed program, including test data, etc.: 1 050 368
Distribution format: tar.gz
Programming language: MatLab (Mathworks Inc.), standard license
Computer: General computer running MatLab (Mathworks Inc.)
Operating system: Windows2000, Windows-XP, Linux
RAM: Of order four times the size of the data file
Classification: 3, 4,14, 18, 23
Catalogue identifier of previous version: ADTV_v2_0
Does the new version supersede the previous version?: yes
Nature of problem: Calibrate optical tweezers with precision by fitting theory to experimental power spectrum of position of bead doing Brownian motion in incompressible fluid, possibly near microscope cover slip, while trapped in optical tweezers. Thereby determine spring constant of optical trap and conversion factor for arbitrary-units-to-nanometers for detection system. The theoretical underpinnings of the procedure may be found in Ref. [3].

Solution method: Elimination of cross-talk between quadrant photo-diodes, output channels for positions (optional). Check that distribution of recorded positions agrees with Boltzmann distribution of bead in harmonic trap. Data compression and noise reduction by blocking method applied to power spectrum. Full accounting for hydrodynamic effects; Frequency-dependent drag force and interaction with nearby cover slip (optional). Full accounting for electronic filters (optional), for “virtual filtering” caused by detection system (optional). Full accounting for aliasing caused by finite sampling rate (optional). Standard non-linear least-squares fitting with custom written routines based on Refs. [1,2]. Statistical support for fit is given, with several plots facilitating inspection of consistency and quality of data and fit.

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★ This paper and its associated computer program are available via the Computer Physics Communications homepage on ScienceDirect (http://www.sciencedirect.com/science/journal/00104655).
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Reasons for the new version: Recent progress in the field has demonstrated a better approximation of the formula for the theoretical power spectrum with corrections due to frequency dependence of motion and distance to a surface nearby.

Summary of revisions:

- The expression for the theoretical power spectrum when accounting for corrections to Stokes law, \( P_{\text{hydro}}(f) \), has been updated to agree with a better approximation of the theoretical spectrum, as discussed in Ref. [4].
- The units of the kinematic viscosity applied in the program is now stated in the input window.
- Greek letters and exponents are inserted in the input window.
- The graphical output has improved: The figures now bear a meaningful title and four figures that test the quality of the fit are now combined in one figure with four parts.

Restrictions: Data should be positions of bead doing Brownian motion while held by optical tweezers. For high precision in final results, data should be time series measured over a long time, with sufficiently high experimental sampling rate; The sampling rate should be well above the characteristic frequency of the trap, the so-called corner frequency. Thus, the sampling frequency should typically be larger than 10 kHz. The Fast Fourier Transform used works optimally when the time series contain \( 2^n \) data points, and long measurement time is obtained with \( n > 12–15 \). Finally, the optics should be set to ensure a harmonic trapping potential in the range of positions visited by the bead. The fitting procedure checks for harmonic potential.

Running time: seconds

References


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Keywords: Power spectrum analysis; Precision calibration of optical tweezers