fastDDM: Accelerating Differential Dynamic Microscopy Analysis

Enrico Lattuada*, Fabian Krautgasser, Fabio Giavazzi‡, Roberto Cerbino
Computational and Soft Matter Physics Group   -   ‡University of Milan
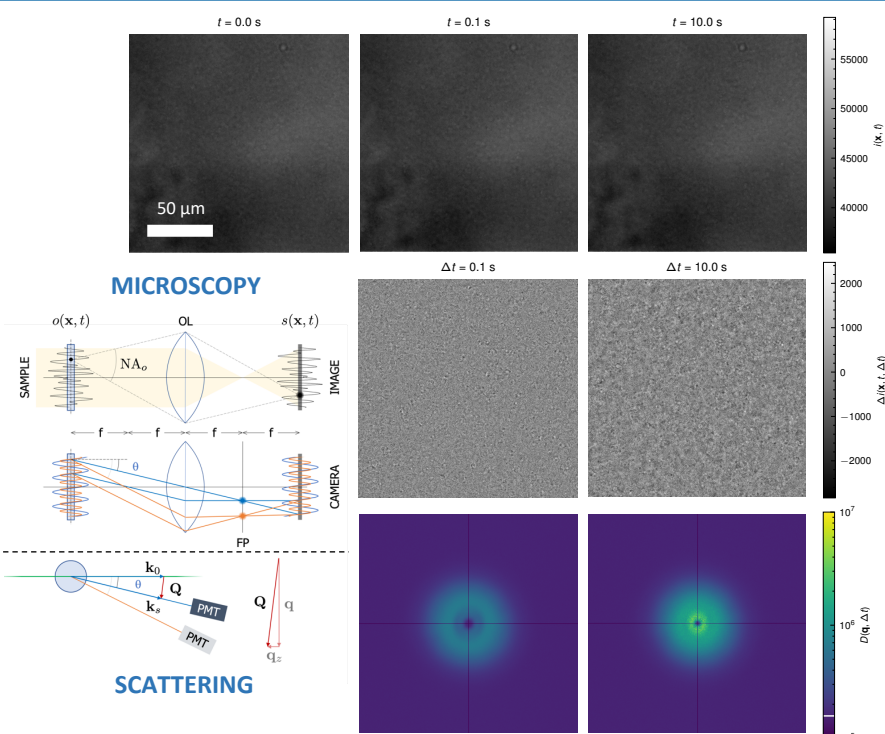
Abstract

Overview: Differential Dynamic Microscopy (DDM) has emerged as a versatile and robust tool to quantify the dynamics of complex fluids and soft (biological) materials. It requires a microscope equipped with a digital camera and yields results analogous to those from multi-angle Dynamic Light Scattering experiments by analyzing microscopy movies of the sample.
Problem: A drawback of DDM is its time-consuming analysis and the lack of open optimized and user-friendly software.
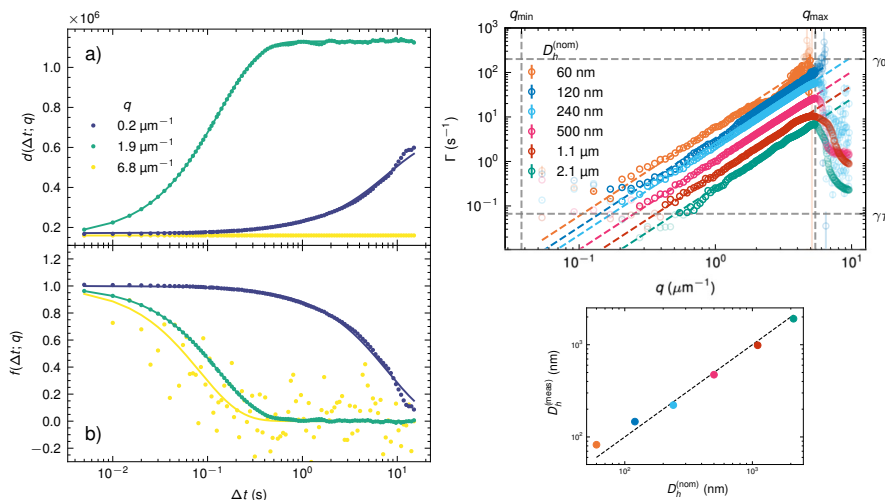**Solution:** Here, we introduce "fastDDM", a Python library designed to enhance the accessibility and interactivity of DDM analysis. Employing cutting-edge algorithms and harnessing the computational power of GPUs, we achieve a remarkable reduction in the analysis time for standard image sequences (10,000 frames, 512x512 pixels) from hours to just seconds.
Examples: We will illustrate the capabilities of this software through practical examples drawn from existing literature, highlighting its potential to accelerate and simplify DDM analysis for researchers across various domains.
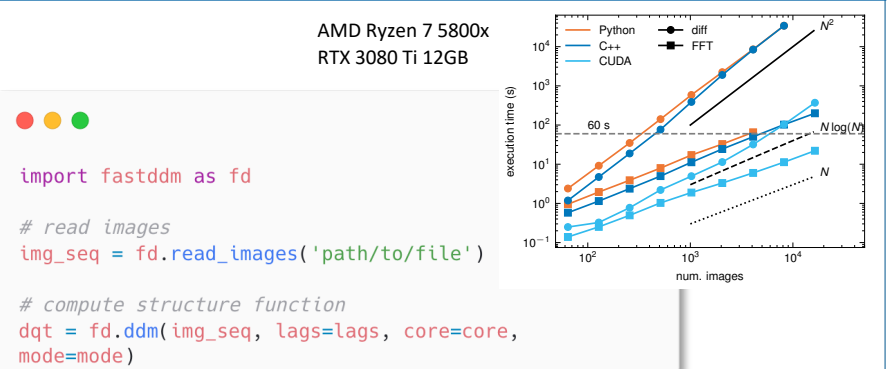
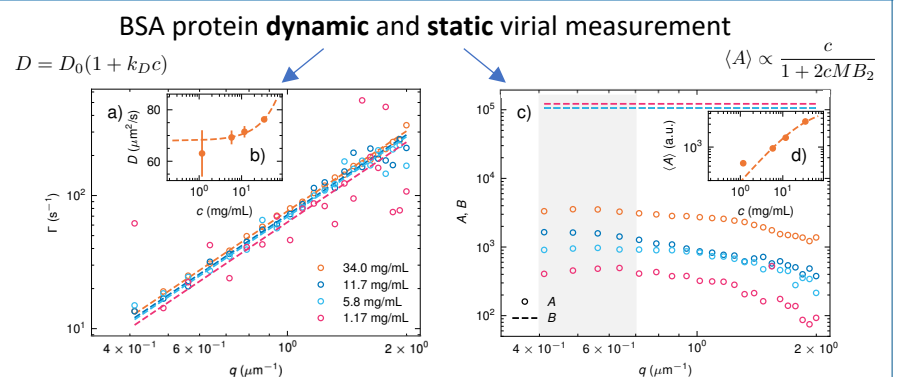## The nuts and bolts of DDM

MICROSCOPY

SCATTERING

$$D(\mathbf{q}, \Delta t) = \langle |\Delta I(\mathbf{q}, t, \Delta t)|^2 \rangle_t = A(\mathbf{q})[1 - f(\mathbf{q}, \Delta t)] + B(\mathbf{q})$$
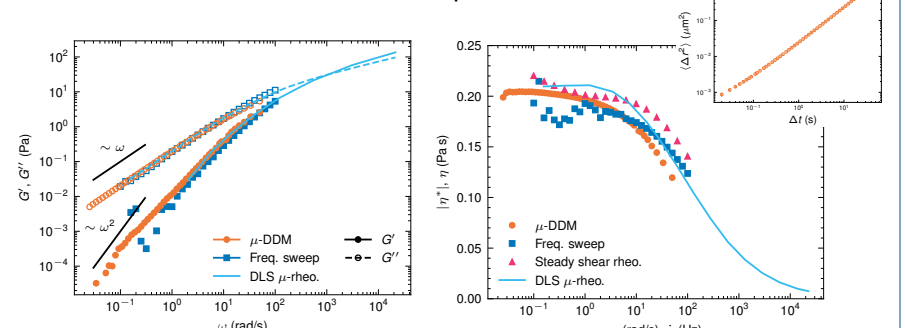

fastDDM: DDM, simple, *now*!

AMD Ryzen 7 5800x
RTX 3080 Ti 12GB

```python
import fastddm as fd

# read images
img_seq = fd.read_images('path/to/file')

# compute structure function
dqt = fd.ddm(img_seq, lags=lags, core=core,
mode=mode )
```


Application 1: Proteins characterization

BSA protein **dynamic** and **static** virial measurement

$$D = D_0(1 + k_D c)$$

$$\langle A \rangle \propto \frac{c}{1 + 2cMB_2}$$

Application 2: Microrheology

PEO $c = 2.1\% wt$ with 330 nm PS spherical tracers

*Contact:
University of Vienna, Faculty of Physics
Boltzmanngasse 5, 1090, Vienna
enrico.lattuada@univie.ac.at

References:
- E. Lattuada, F. Krautgasser, F. Giavazzi, R. Cerbino, *J. Chem. Phys.* (2023, in preparation)
- J.J. Bradley et al., *Soft Matter* (2023), **19**, 8179
- C. Guidolin et al., *Macromolecules* (2023), **56**, 8290
- M.A. Escobedo Sanchez et al., *Soft Matter* (2018), **14**, 7016