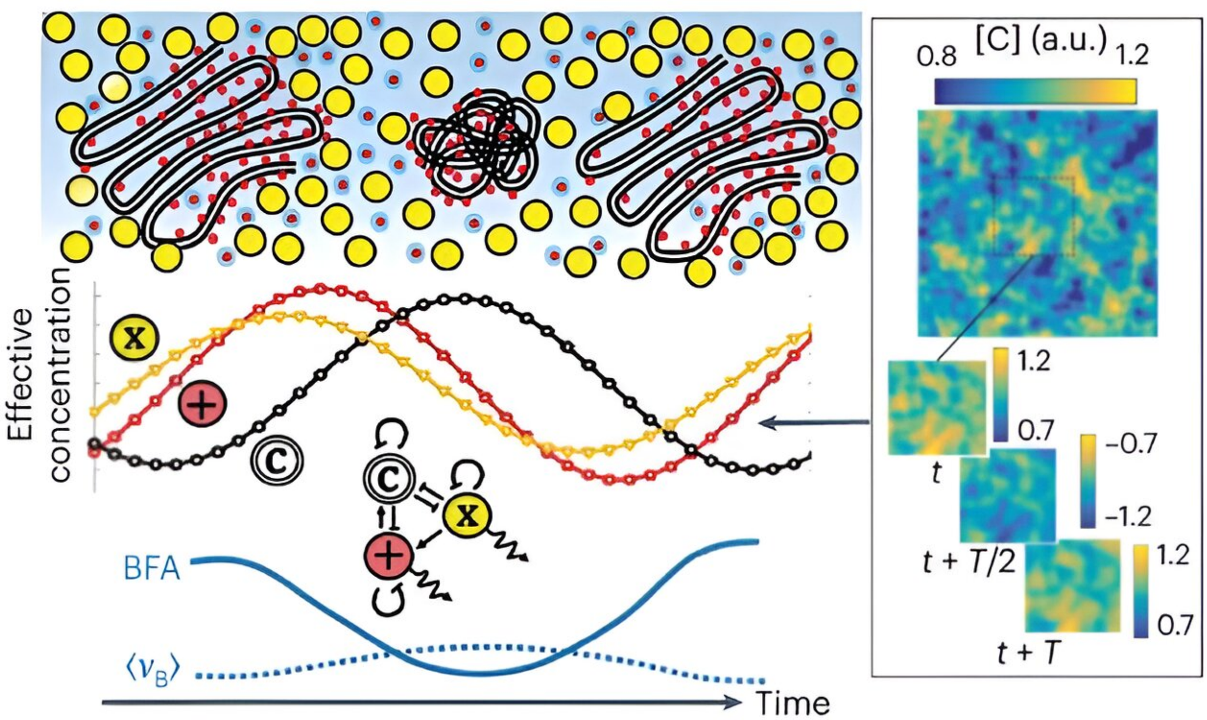
New technique visualizes mechanical structure of the cell nucleus for the first time

New technique visualizes mechanical structure of the cell nucleus for the first time

January 18 2024



Schematic of the three-species model (+, fast diffusing species; x, slow diffusing species, black/white, condensed chromatin) used in the simulation, showing the calculated temporal evolution of species concentrations and BFA for stable STOS. Inset: evolution of spatial maps of condensed chromatin concentration [C] for a STOS with period T. Credit: *Nature Photonics* (2024). https://www.nature.com/articles/s41566-023-01368-w

The cell nucleus is considered to be the control center of vital cellular processes, but its material properties continue to puzzle scientists. An international research team led by MedUni Vienna has now developed a new technique that provides a previously unattainable view of the mechanical properties inside this control center.

For the first time, it has been possible to visualize over time its peculiar dynamic structural features in living cells, which appear to be crucial for cell function. The study results, recently published in *Nature Photonics*, can contribute to a better understanding of the fundamental processes of life.

Researchers have long been interested in the mechanical properties of the cell nucleus. It is known that these must be well regulated for the cell to function properly and that they can change in the course of various diseases. It is also known that the cell nucleus can behave both as a liquid and as a solid, yet it is unclear how these properties can lead to vital processes such as the reorganization within the nucleus during cell division or the rapid and highly effective synchronization of processes in different areas of the nucleus.

Highly dynamic structure visualized

The research team led by Kareem Elsayad from MedUni Vienna's Center for Anatomy and Cell Biology (a part of the Medical Imaging Cluster at MedUni Vienna) has now come closer to answering these questions. The scientists have developed a technique with which complex mechanical features in the cell nucleus can be imaged, in living cells over time. The method is based on a process called Brillouin light scattering, which measures the scattering of light from constantly present thermal vibrations in a sample.

The spectrum of the scattered light can be used to calculate the elasticity and viscosity of a sample in the direction in which the light is scattered. By measuring this from all angles at the same time, the scientists were able to create spatial maps of the cell nucleus that reveal how its mechanical structure changes over time. They found that it is not only highly dynamic but also possesses a peculiar long-range order that may be responsible for synchronizing processes in the nucleus.

Understanding the development of diseases

"What we can visualize with our technology is fascinating and in a way groundbreaking," says study leader Elsayad. "The unusual properties we observe give us some insight into how the cell nucleus is able to synchronize vital processes so quickly and efficiently, and in such a directed way, despite usually looking like just a messy warm soup."

The results could also contribute to a better physical understanding of pathological anomalies that are associated with changes in nuclear processes. Future studies using the new technology are expected to build on these findings, for example, to clarify the key molecular players and environmental factors that underlie the curious mechanical and structural properties of cell nuclei.

More information: Hamid Keshmiri et al, Brillouin light scattering anisotropy microscopy for imaging the viscoelastic anisotropy in living cells, *Nature Photonics* (2024). DOI: 10.1038/s41566-023-01368-w. www.nature.com/articles/s41566-023-01368-w

Provided by Medical University of Vienna visualizes-mechanical-cell-nucleus.html