Spatial and Temporal Resolution for Soft Condensed Matter

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Soft condensed matter covers the major disciplines of Biology, Chemistry, Physics and Materials Science delivering structural and dynamic information in nanoscience, mesoscopic architectures, supramolecular structures, and nucleation/growth of crystals. X-ray scattering and diffraction is an essential complement to the microscopies and its contribution to soft-condensed matter research is also proving important in archaeological, environmental; and conservation sciences, further indicating its ability to span wide ranging scientific disciplines. The structures of interest cover length scales from 0.1 nm upto microns, the materials themselves often have considerable texture so it is important to cover a wide range of reciprocal space in two dimensions.

The understanding of the morphology of soft materials and the way this can be manipulated by interfacial effects provide ways of creating new materials and adding value to commodities. These complex and usually heterogeneous materials are typified by polymers, gels, particulates and colloidal dispersions, whose properties often seem intermediate between ordinary liquids and solids. In many cases, these materials do not consist of a single phase, and are dominated by the properties of the components and their interfaces. In some situations such materials are used in the form of thin films, coatings or multilayers, while in other circumstances it is the bulk properties of the material that dominates its functionality. In all these situations, it is the properties of the morphology and internal interfaces that are important. For example, the bulk mechanical properties of composites and blends can be dramatically changed by modifications at the molecular level of their internal interfaces. In a wide variety of industries achieving an understanding of the relationship between processing, structure and properties is a high priority. This includes polymer processing, where it is the evolution and subsequent kinetic arrest of phase structure during processing that controls structure and properties, as well as the food industry, where strikingly analogous considerations enter into the processing of the complex biopolymer mixtures that make up foodstuffs.

The fundamental user requirements for new detectors for new science are wide range of coverage of q-space and adequate temporal resolution. To maximise efficiency of data collection banks of detectors are required, analogous to the current SAXS/WAXS configurations, but with area detectors. The detector should have pixels that over-sample the beam size by a factor of 2, i.e. are half the size of the incident beam, so that the data density increase as q decreases. We will ask the question – is there a fundamental difference in the detector requirements for scattering, which is relatively smooth, and diffraction with sharp peaks? But what does “adequate” time resolution mean? For macromolecules this could be micro-seconds but the majority of experiments never use more than millisecond time resolution.