KOOKABURRA, THE ULTRA-SMALL-ANGLE NEUTRON SCATTERING INSTRUMENT (USANS) AT ANSTO: DESIGN AND RECENT APPLICATIONS

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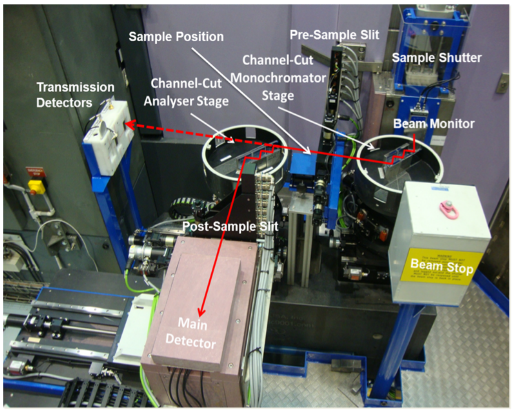
The Ultra-Small-Angle Neutron Scattering (USANS) instrument KOOKABURRA allows characterisation of microstructures covering length scales in the range of 0.1μm to 10μm. USANS is useful for studies of pores and cracks in rocks, cement or engineering materials, very large biological or polymer molecules, hierarchical soft matter systems, macromolecular assemblies, and mesoscopic magnetic particles among others.

KOOKABURRA INSTRUMENT:

KOOKABURRA applies the classical Bonse-Hart method [1] which consists of using two multiple reflection crystal systems arranged in non-dispersive geometry to achieve a steep decrease of the tails of the perfect crystal diffraction curves. This technique permits to detect very small angular deviations of the neutron beam after scattering from a sample placed between the two channel-cut crystals [2].

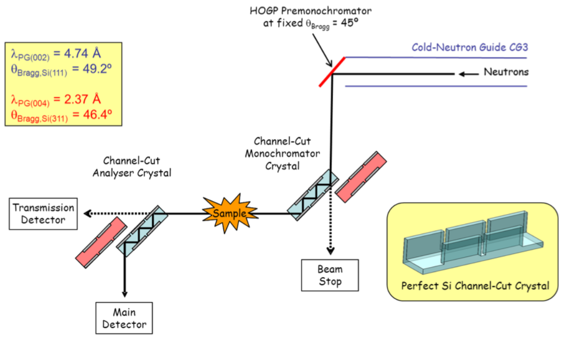
The q-resolution limit is given by the Darwin width of the perfect Si crystal according to: qmin = $4\pi\theta_D/\lambda$ (Å^{-1}). The versatile KOOKABURRA has one sample position equipped with two interchangeable sets of channel-cut crystals, Si(111) and Si(311), allowing individual operation at different wavelengths [3,4]. Therefore, the instrument is able to optimally accommodate weakly and strongly scattering samples.

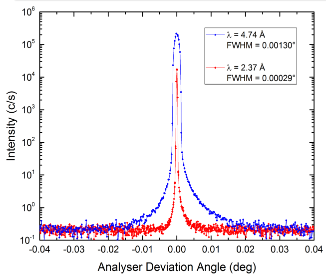


APPLICATIONS:

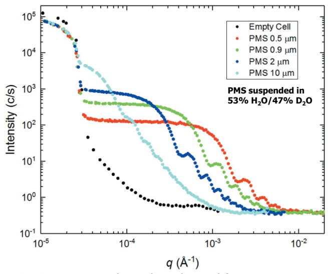
The range of interest includes bacteria, blood, cements, clays, clusters in metals, coals, colloids, complex fluids, emulsions, foams, food, gels, granular materials, hydrogels, membranes, micellar systems, minerals and mineral processing, nanocomposites, nanotechnology, phase transitions, polymer blends, polymers, porous materials, powders, precipitates, proteins, rocks, thin metallic or organic films, viruses, etc.

Instrument characteristics	High-Intensity Operation Mode	High-Resolution Operation Mode
Wavelength λ	4.74 Å	2.37 Å
Premonochromator	HOPG(002) at θ_B = 45°	HOPG(004) at θ_B = 45°
Channel-cut crystals	Si(111) at θ_B = 49.2°	Si(311) at θ_B = 46.4°
Full Darwin width, $2\Delta\theta_D$	21 μrad	5.04 μrad
Minimum momentum transfer, q_{min}	3×10^{-5} Å	1.5×10^{-5} Å
Vertical q resolution, Δq_{ver}	0.0586 Å	0.117 Å
Wavelength resolution, $\Delta\lambda/\lambda$	3.5%	2.0%
Neutron flux (beam 5 cm × 5 cm)	215000 cm^{-2} s^{-1}	17500 cm^{-2} s^{-1}
Noise-to-signal ratio (empty beam)	1.1×10^{-6}	1.3×10^{-5}

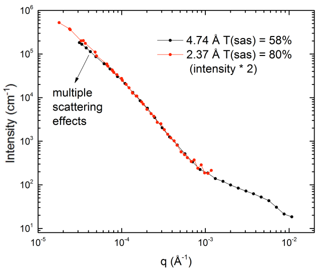




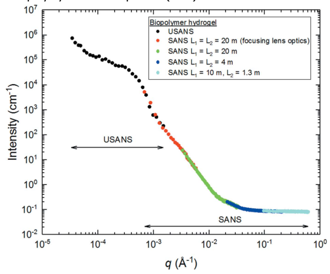
Intrinsic analyser rocking curve profiles of the KOOKABURRA USANS instrument.



USANS experimental raw data obtained from measurements on polystyrene microspheres (PMS) with various diameters.



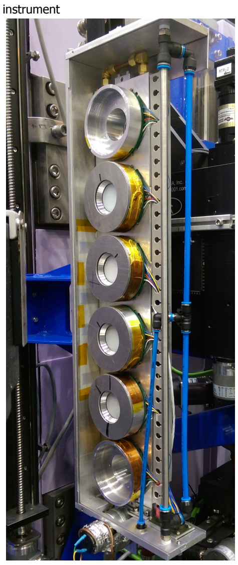
USANS data measured at two different wavelengths. Effect of multiple scattering shown. Yang et al., RSC Adv., 2015, 5, 107916-107926.

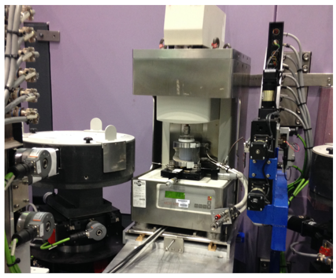


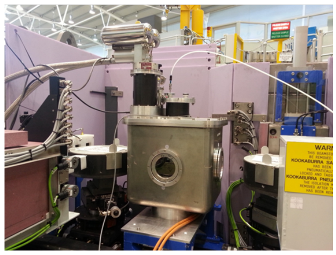
SANS and USANS scattering data from a biopolymer hydrogel. A total of five different instrument configurations had been used. Martínez-Sanz et al., 2016, 105, 449-460.

SAMPLE ENVIRONMENTS:

Temperature controlled rotting multi-sample tumbler installed on USANS instrument







On the KOOKABURRA instrument sample environment equipment can be placed between the perfect Si crystal monochromator and analyser stages. Top: A rheometer for shear cell experiments. Bottom: A high-field magnet with cryostat temperature control.

[1] Bonse, U. and Hart, M. Applied Physics Letters, 7, 1965, 238-240. [2] Agamalian, M., Carpenter, J.M, and Treimer, W. Journal of Applied Crystallography, 43, 2010, 900-906. [3] Rehm, C., Brûle A., Freund, A.K., Kennedy, S.J., Journal of Applied Crystallography, 46, 2013, 1699-1704. [4] Rehm, C. et al., Journal of Applied Crystallography, 51, 2018, 1-8.

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