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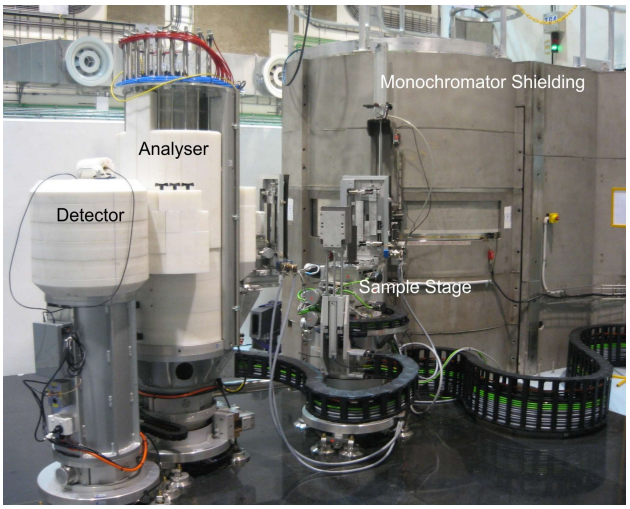
Australian Centre for Neutron Scattering (ACNS)

Taipan

Thermal Triple-Axis and Filter Spectrometer

Taipan is used to study the collective motion of atoms, phonons and magnons in materials, and phase transitions and processes involving thermal energy. When the filter spectrometer is used instead of the triple-axis spectrometer vibrational density of states may be directly measured.



Inelastic scattering

Neutrons penetrating a sample lose or gain energy during scattering which provides information on interatomic forces and movement of atoms in the sample.

What makes Taipan special?

Triple-axis spectrometer:

- Measures how much energy has been lost or gained by neutrons in the scattering process, providing information on the energy spectrum of the solid sample and hence vibrational dynamics
- Analyse the energy of the scattered neutrons allowing purely elastic scattering to be measured with very low background signal.

Filter spectrometer:

- Integrates scatter over a larger solid angle over a fixed energy window. The spectrometer is ideal for measuring molecular vibrations in powders that involve hydrogen. A weighted vibrational density of states is obtained.

Applications

- How materials change structure (phase transitions, eg. from liquid to solid)
- Other thermodynamic properties of solids (eg. specific magnetic susceptibility)

Taipan is highly configurable and versatile, and has the most intense thermal beams at ANSTO, together with the lowest background levels.

SPECIFICATIONS

Angular range:
- $16° < 2\theta_m < 85°$ / $-145° < 2\theta_s < 115°$ / $-110° < 2\theta_A < 110°$

Monochromators:
- Pyrolytic Graphite (002) with Energy Range: ~ 5 – 70 meV
- Copper (200) with Energy Range: ~ 14 – 200 meV
- 200 x 200 mm² in 9 x 11 segments (W x H) with continuous horizontal and vertical focussing

Sample area:
- Beam size at monochromator shielding exit 50 x 130 mm (w x h)
- Flux at sample position ~ 2 x 10^8 ncm^{-2}s^{-1} at 50 meV

Analyser:
- Pyrolytic Graphite (002) 24' mosaic
- 160 x 140 mm in 5 x 7 segments (W x H) with continuous horizontal and vertical focusing

Polarisation analysis:
- Provided by 3He spin filters before and after the sample.

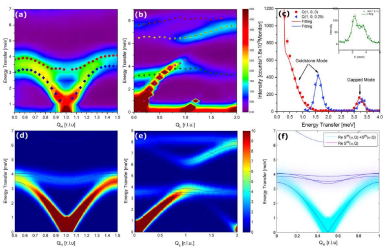
Soller collimators:
- Pre-monochromator collimators: 15', 30', Open; 90 x 185 mm² (w x h)
- Post-monochromator, pre-analyser and pre-detector, collimators: 20', 40', Open; 50 x 130 mm² (w x h)

Detector:
- 3He detector, Ø25 mm x 100 mm, p=10 bars

CASE STUDIES

Spin dynamics in $Co_4Nb_2O_9$

The spin-wave excitations of $Co_4Nb_2O_9$ were measured by using inelastic neutron scattering and simulated by a dynamic model involving nearest- and next-nearest-neighbour exchange interactions, in-plane anisotropy, and the Dzyaloshinskii-Moriya interaction. The in-plane magnetic structure of $Co_4Nb_2O_9$ is attributed to the large in-plane anisotropy, while the noncollinearity of the spin configuration is attributed to the Dzyaloshinskii-Moriya interaction.

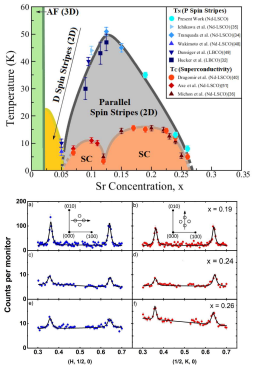


Deng *et. al.*, Phys. Rev. B 97, 085154 (2018)

Stripes and superconductivity in $La_{1.6-x}Nd_{0.4}Sr_xCu_2O_4$

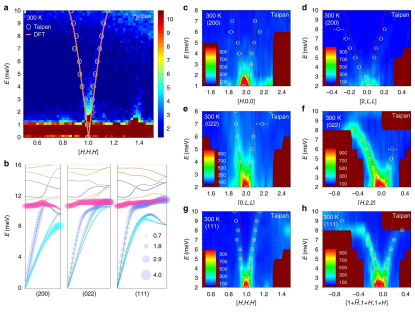
Quasi-two dimensional quantum magnetism is highly correlated with superconducting ground states in Cu-based High T_C superconductivity. Taipan results show that two dimensional, quasi-static, parallel spin stripes are observed to onset at temperatures such that the parallel spin stripe phase envelopes all superconducting ground states in this system.

Ma *et. al.*, Phys. Rev. X (2020)



Low thermal conductivity in an excellent acoustic conductor

A solid with larger sound speeds usually exhibits higher lattice thermal conductivity. Here, CuP_2 has a large mean sound speed of 4155 m s^{-1}, comparable to GaAs, but single crystals show very low lattice thermal conductivity of about 4 W m^{-1} K^{-1} at room temperature, one order of magnitude smaller than GaAs. This study combined neutron scattering techniques with first-principles simulations. From Taipan results, the Cu atomic dimers vibrate as a rattling mode with frequency around 11 meV, which is manifested to be remarkably anharmonic and strongly scatters acoustic phonons to achieve the low lattice thermal conductivity.

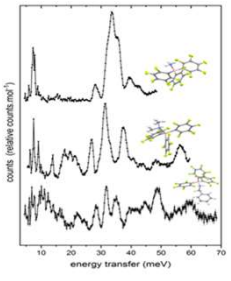


Qi et al., Nat Commun **11,** 5197 (2020).

The mechanics of aminoboranes

Aminoboranes are used as a basis in many chemical synthetic processes. They are also interesting to study in terms of hydrogen bond accepting groups.

- Nice examples of relatively isolated rotors & associated groups.
- The strong Me group rotor at ~33 meV shows very little temperature dependence (a very slight softening as T rises).
- The dimethyl has strong additional rotor features - Me coupling?
- The benzyl has a far more complicated spectrum with intensity distributed across many modes as the larger amino-chain moves.



Stride and Stampfl: 2018