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NEUTRON BEAM CHOPPERS - A SIMPLE GUIDE

Why do we need them and what do they do?

All of the ISIS beamline instruments record the 'Times of Flight' (T.O.F.) of the neutrons, from the instant (t=o) they are formed, at the spallation target, to the moment they arrive at the detectors of the instrument. From this basic data and with knowledge of the instrument geometry and characteristics, the scientists can calculate the original velocity and hence the energy of each neutron and the changes in energy which they suffered as they interacted with the atoms of the samples under investigation. From this they can determine the relative positions and movements of these atoms.

Because the ISIS spallation source is producing 50 pulses of neutrons every second, the data-logging computers have a 'time frame' of only one fiftieth of a second to record the data from each pulse. However, because of the wide range of speeds of the neutrons in each pulse, the difference in T.O.F. for the fastest and slowest neutron in a single pulse may exceed this 1/50 s. Unless some technique is used to limit the range of velocities from each pulse 'Frame Overlap' may occur where neutrons from several pulses are logged in the same data frame. The data is thus jumbled and difficult or impossible to analyse. One of the techniques used to limit the range of energies passed by an instrument is the "neutron chopper".

For certain ISIS instruments neutrons with a very narrow band of velocities are required. By analogy with light rays such neutrons are termed 'Monochromatic' (Single Colour) and the neutron choppers used for these are called 'Monochromating Choppers'.

How do they work?

Neutron choppers are moving shutters of neutron opaque material the operation of which is comparable to the shutter of a camera. This opens to allow just the light required for a certain photograph to pass. But whereas in the case of light all wavelengths (colours) travel with the same speed and therefore pass the shutter at the same instant, for our case a wide range of speeds are emitted by the ISIS source and so, dependant on its distance from the source, a particular neutron shutter will pass a sequence of neutrons of diminishing speeds the limits of which can be chosen by adjusting the opening and closing times (phasing) of the shutter relative to the instant (t=o) of a particular ISIS neutron pulse.

Because the chopper must pass exactly the same energies for each pulse and operate 50 times each second, non-stop for weeks on end, the type of movement we use for the shutter is rotation as this gives us the best phase control and reliability of operation.

Some Interesting Chopper Statistics

Type	Rotational Frequency (Hz)	Peripheral Speed	Revolutions Per Year (1 Billion=10^9)	Distances travelled Per Year by a point on the rim im multiples of:-	
				Distance around the earth	Distance to the moon
i) Nimonic	100	~200m/s (700 km/h)	3.2 Billion	x 154	x 16
ii) Disc	50	~100m/s (350 km/h)	1.6 Billion	x 77	x 8
iii) Fermi Drum	600	226m/s (814 km/h)	19 Billion	x 178	x 19