New Instruments & upgrades

CYCLOPS is looking pretty good

B. Ouladdiaf, on behalf of the CYCLOPS team
(ouladdiaf@ill.eu)

The present general-purpose ILL thermal-neutron Laue diffractometer, VIVALDI [1], has demonstrated in a spectacular manner the advantages of the Laue technique with a large solid angle of detection, especially for small or weakly-scattering crystals, although it is limited in some applications by the slow read-out of its image-plate detector. By contrast, on the CCD-based flat-plate Laue diffractometer OrientExpress [2], the 1680 x 1320 pixel image is read out in less than 0.2 sec. The new single-crystal Laue diffractometer CYCLOPS will combine the principal advantages of VIVALDI and OrientExpress, to offer a unique instrument for real-time exploration of reciprocal space and rapid data collection through phase transitions

CYCLOPS (CYlindrical Ccd Laue Octagonal Photo Scintillator) is composed of an octogonal detector, essentially eight copies of the OrientExpress detector, a sample table equipped with an ω rotation and X,Y and Z translations. The instrument control software MAD and DTI, running under Linux, controls the motors, the sample environment and interfaces to the data acquisition program which runs on an adjacent PC under Windows The diffractometer is located at the end of the H24 thermal neutron guide (Figure 1).

The detector is a unique product allowing electronic capture of neutron diffraction patterns over a 180° horizontal and 50° vertical field of view. It is based upon eight high performance thermoelectrically-cooled image-intensified CCD cameras. These cameras view an octagonal array of large-area neutron scintillators via fast close-focus f0.95 lenses inside a light-tight enclosure. The neutrons pass through this enclosure along a light-tight pipe through the centre of two opposing scintillators. A pair of cameras views each facet of the octagonal scintillator array which ensures that the beam pipes do not obscure any part of the scintillators from the cameras' view.

Within the cameras, coupling between the intensifier and CCD is done via a tapered fibre-optic, bonded directly onto the CCD, to give maximum transmission and high sensitivity. The neutron scintillator is of AST type ND blue, based upon Li6 with added ZnS:Ag to provide high neutron capture efficiency and low γ-ray efficiency, to provide good discrimination. The scintillator thickness is 0.21mm.

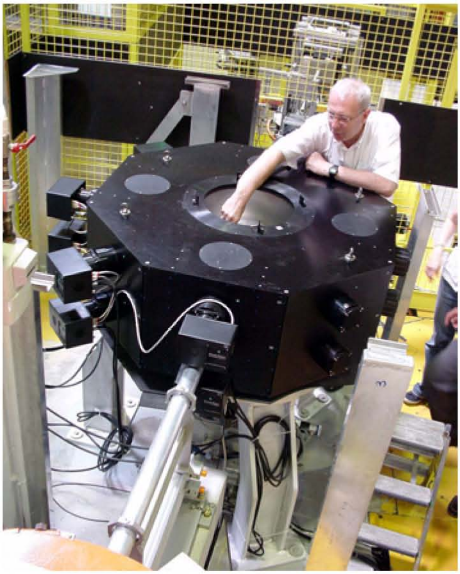

Figure 1: Cyclops with a binocular engineer.

The total active scintillator area of (4 x) 400 x 166 mm^2 is rendered as a single image in 8, 12 or 16-bit TIFF format of 3840x2400 pixels.

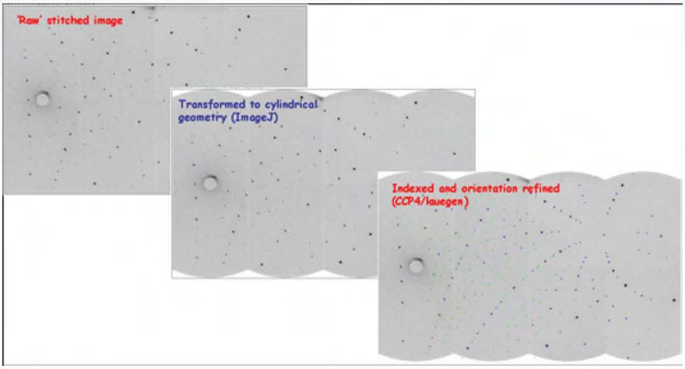

Figure 2: Laue pattern obtained with a ruby crystal in 20s

Each pixel is 172 µm on edge. The total readout time is about 1 s. The free diameter of 380mm around the sample, three-times larger than that of VIVALDI, will permit a wider range of sample environment, including large pressure cells and cryomagnets.

The first measurements with half the cameras on the same thermal beam as OrientExpress have exceeded our expectations; they promise exciting new applications for neutron Laue diffraction. Indeed, figure 2a shows the raw stitched Laue pattern obtained with a ruby crystal in 20s of acquisition time. Figures 2b and 2c show the patterns transformed to cylindrical geometry and indexed and orientation-defined, respectively.

The acquisition time can be even shorter, opening new opportunities for rapid nuclear structure determination since a complete data collection is possible in a few minutes. Mosaic spread, twinning of crystals, and preferred orientation in textured samples can also be investigated in very short measuring time. Nuclear and magnetic phase transitions, diffuse scattering and magnetic domains can also be studied.

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References:

[1] G.J. McIntyre, M.-H. Lemée-Cailleau and C. Wilkinson, Physica B 385-386 (2006) 1055-1058

[2] B. Ouladdiaf, J. Archer, G J. McIntyre, A.W. Hewat, D. Brau and S. York, Physica B 385-386 (2006) 1052.