ESRF	**Experiment title:** HIGH RESOLUTION MAPPING OF STRESS FIELDS AROUND CRACK TIPS	**Experiment number:** HS-307
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Report:

In this experiment we examined the two-dimensional strain state existing around the tip of a fatigue crack grown into a well-characterised single edge notched bending specimen, 6mm thick, and of 12 x 100 mm in-plane dimensions, made of tine grain sized ($< 5\ \mu m$) 2124 Al alloy. The specimen contained high macroscopic residual stresses produced during quenching, which ensured that the crack remained open at the tip even in the absence of loading. Furthermore, a special four-point bending *in situ* loading rig was used to produce marked stress intensification. A lateral spatial resolution of $250\mu m$ was used in this experiment, and the specimen was scanned across the beam in order to map the strains in the near crack tip region. The data were collected in the form complete diffraction rings recorded by a CCD camera. This was done with the aim of extracting maximum information from the measurements, by developing correct interpretation for the variation in the ring patterns between successive measurements. Good peak intensity was obtained with fairly fast data acquisition times (<30secs), which, coupled with automated image acquisition and specimen translation, allowed efficient data collection to be achieved.

Most important conclusions drawn from earlier experience (see ESRF experiment report HS-21) were summarised as follows:

1. Spatial distortion introduced by the CCD camera is probably too large to allow for efficient correction for the purposes of extracting strains to the desired accuracy of $<100\mu\varepsilon$. An alternative approach based on incremental comparison between images, possible including the use of a powder standard, is preferred;

2. In view of the above, ellipse fitting should not be attempted, since the ring shapes are dominated by distortion/correction effects. Instead, polar re-binning and single line peak fitting should be employed. In particular, fast re-binning is important for efficient analysis. The corresponding program must be optimised for speed, which implies the exclusion of available data analysis packages (IDL, Matlab, Mathematics, Fit2D) in favour of writing the routine in C or Fortran, etc.

An example of the first results obtained using the approach described above is presented in Fig. 1, which shows the measured millistrain values in the loaded specimen. The axial strain component in the crack opening direction is plotted as a 3D graph over the near tip region. These measurements show good agreement with, and significant improvement (e.g. in terms of spatial resolution) over earlier results obtained in a similar configuration using neutrons.

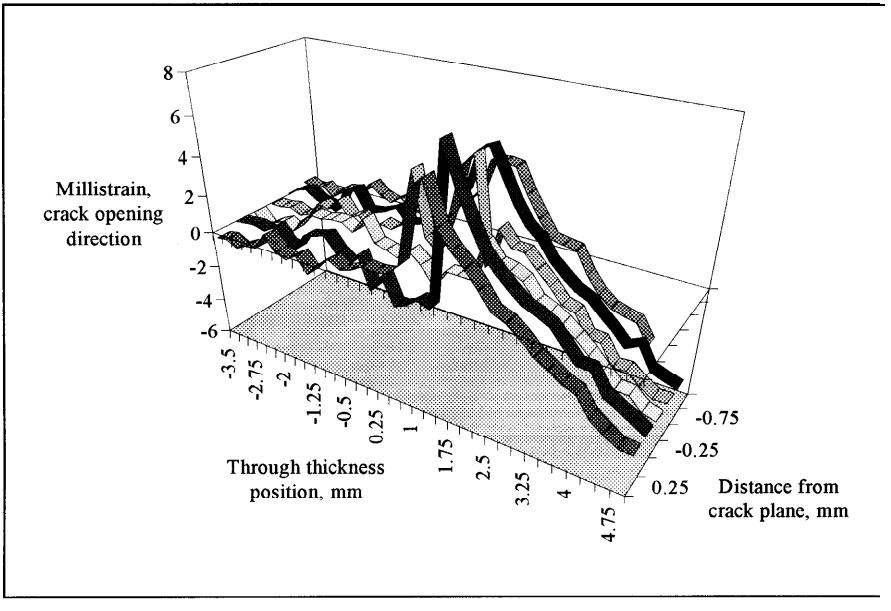

Fig.1. Millistrain (mε) in the crack opening direction mapped around the crack tip.

In our view the results obtained in this experiment represent a significant development in the use of synchrotron X-ray radiation for the measurement of strains in engineering components (see also ESRF experiment report HS-300). Refinement achieved in the analysis methods and interpretative software provided clear confirmation of the method's viability, accuracy and competitiveness for the tasks on which we have focused our attention. Further work on the extensive collected data is under way. It is aimed at extracting and presenting the full amount of strain state information contained in the diffraction patterns. The results are likely to be submitted for publication in the near future.

A important aspect of the present activities at Newcastle, Cambridge and Salford concerns the identification of the essential and necessary alterations which must be introduced into the experimental setup and data collection. These are absolutely vital for optimising the method's performance, and can only be adequately formulated and implemented in the course of a long term programme focusing on the methodology of synchrotron X-ray strain measurement using ID1 1. A proposal for such programme forms the topic of an application for longer term project time allocation which accompanies this report.