Nanoscale self-organisation of electron orbital populations, and hence control of bulk electronic properties, has fascinated scientists for many years [1]. The bilayer manganites are an especially interesting series of compounds with prominent two-dimensional behaviour; which have been shown to exhibit colossal magneto-resistance close to room temperature [2]. Recently a study of Pr(Sc1−yCa0.9)y2Mn2O7 has revealed an interesting twist, with the observation of a temperature induced rotation of the Mn3+ orbital order stripe[3].

The phase diagram of Pr(Sc1−yCa0.9)y2Mn2O7 shows a number of different magnetic and electronic order phases, that are accompanied by structural transitions. Although the presence of charge and orbital order has been verified through optical anisotropy and resistivity measurements, the details of this throughout the series have yet to be established. Orbital order is typically accompanied by a concomitant structural distortion that is formed through a change in bond length in the MnO6 octahedra established through a preferential orbital occupation. This Jahn-Teller distortion has been observed in the La2−2xSr1+2xMn2O7 bilayers, through resonant and high energy x-ray diffraction[4].
We have used resonant x-ray scattering at P09 to investigate the competing order parameters in Pr(Sr$_{0.2}$Ca$_{0.8}$)$_2$Mn$_2$O$_7$ ($y = 0.8$), which appears to show completely different behaviour to that observed in Pr(Sr$_{0.1}$Ca$_{0.9}$)$_2$Mn$_2$O$_7$ ($y = 0.9$). Below the charge and orbital transition at 310 K, we observe a splitting in the (100) reflection and the appearance of split superlattice reflections at (0.5,0,0), and (1.5,0,0) (Fig. 1). The (010) reflection remains a single reflection and there is no (0,0.5,0) or (0,1.5,0) reflection, showing that the charge and orbital order is restricted to the $h$ direction.

Using a combination of energy scans and by comparing the intensity in the $\sigma - \pi$ and $\sigma - \sigma$ channels, we determined that all the reflections at (1,0,0) are charge based in origin (either due to charge order or a weakly allowed Bragg reflection). By contrast, at the (0.5,0,0) and (1.5,0,0), one peak in each split-reflection appears to be due to an electric quadrupole, and the other an electric dipole (charge). The anisotropy of the electric quadrupole (orbital order), was measured through full linear polarisation analysis (Fig 2), which fits a simulation of orbital order. To further understand the origin of the splitting of the reflections we are undertaking sensitive single crystal structural determinations at different temperatures. The analysis of these results are ongoing.

References