ESRF	**Experiment title:** X-ray Magnetic Scattering from $PrBa_2Cu_3O_{6.92}$	**Experiment number:** HE-197
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Report:

One strategy in the attempt to elucidate the mechanism for high temperature superconductivity is to study compounds in which the superconductivity is anomalously suppressed. Such an approach has, for example, recently paid great dividends in the study of $La_{0.875}Ba_{0.125}CuO_4$, in which it was revealed that the destruction of superconductivity is associated with the pinning of incommensurate charge and spin stripe modulations. Models for a pairing mechanism based on a dynamic form of such correlations have recently been constructed.

Another example of the anomalous suppression of superconductivity is the Pr member of the $RBa_2Cu_3O_7$ series, where R=Y or a rare earth element. While the other members of the series are superconductors with $T_c \sim 90$ K, $PrBa_2Cu_3O_{6+x}$ is not superconducting down to the lowest temperatures studied to date. It also exhibits a number of other unusual properties. In particular, it is an antiferromagnetic insulator for all x, with the copper sites ordering between 250-350 K. Further, the Pr moments themselves order between 10 and 20 K, an order of magnitude higher than the ordering temperatures for the other rare-earths in the series, which order between O-2 K. These observations are particularly puzzling in light of the fact that the hole density in the CuO planes and chains is believed to be the same as the superconducting members of the series.

Of great interest is the Pr site magnetism; the anomalously high Pr ordering temperature suggests that the Pr-Pr magnetic coupling may be enhanced by electronic interactions with the CuO_2 planes and thence that the anomalous Pr magnetism and the suppression of superconductivity share a common origin. An improved understanding of the Pr magnetic ordering could therefore help to explain the absence of superconductivity.

In preliminary experiments at X22C, at the National Synchrotron Light Source, USA, we discovered that Pr orders in a long period incommensurate structure at 18 K, by performing resonant x-ray magnetic scattering at the Pr LII edge. This technique allows for the study of the Pr magnetism without significant contribution from the copper order. However, the scattered intensities were not sufficient to allow a detailed study of this new phenomenon. At ID20, we obtained count rates 50 times larger (70 counts per second) and performed quantitative measurements of the incommensurate structure. We find that it is highly ordered in plane, but less well ordered along the c-axis, and that the incommensurability exhibits a weak temperature dependence, increasing by approximately 10% on warming from base temperature (4 K) up to 18 K. In addition, the energy lineshapes at both the LII and LIII edges were characterized. Interestingly, the LIII resonance was significantly narrower than the LII, for reasons that are not yet clear.

Perhaps the most significant result of the work at ID20 was the observation of non-resonant scattering from the antiferromagnetic Cu order. A peak of 10 counts per second was observed at the (0.5,0.5,9) antiferromagnetic Bragg position. The intensity was observed to decrease by approximately a factor of two on cooling through the Pr ordering temperature. While these data are still quite preliminary, they are consistent with a model in which one component of the in-plane copper moment remains commensurate and the other is driven incommensurate, as the Pr order. Work is planned in the near future to confirm and extend these non-resonant results. Specifically, the temperature dependence of the Cu order needs to be characterized, with particular reference to intensities and magnetic correlation lengths above and below the Pr ordering temperature. The energy dependence of the scattering near the Cu K-edge is also of great interest in the context of understanding resonant magnetic scattering at transition metal K-edges.

Finally, the observation of the small signals associated with non-resonant magnetic scattering from the S=1/2 copper moments suggests that the technique could be a useful tool in the study of magnetism in high temperature superconductors and other transition metal compounds. In particular, the method offers the advantages over magnetic neutron diffraction, of providing high reciprocal space resolution and of energy integrating the scattering over all relevant energies.