Put X-Ray Polarimetry on the MAP!

Martin C. Weisskopf (NASA/MSFC)

With Prof. R. Novick and others at the Columbia Astrophysics Laboratory I help found the field of X-ray polarimetry in the early 1970s. Currently I have more experience with the design, construction, calibration, and space flight of such instruments than anyone on the planet. The early probing beginnings saw only one definitive measurement (that of the integrated low-energy X-ray emission from the Crab Nebula sans pulsar) and a number of upper limits. The limited success did nevertheless inspire a number of detailed theoretical calculations, concentrating at first on neutron stars and black holes showing how precise measurements (e.g. degree of polarization and position angle as a function of pulse phase) would provide definitive limitations on otherwise equally plausible theoretical models. Over time the theoretical foundation has grown (e.g. the proceedings of the X-Ray Polarimetry Workshop held at SLAC in 2004). I will outline these foundations.

It is important to understand the history of X-ray polarimetry beyond the early excitement. A polarimeter was at the focus of the original Einstein mission but was dropped during the restructuring. A polarimeter was successfully proposed (R. Novick PI, I was a Co-I) and built for the original Spectrum-X mission. During the years before the cancellation of Spectrum-X, the potential flight of this device stood in the way of other space flights for polarimeters --- “let us wait and see what it finds”. This was unfortunate as there were a number of reasons why that polarimeter should not have been flown on the mission. Perhaps the most significant (but not only) reason was that a shared focal plane provided very little observing time. This is an extremely important point in considering the Roadmap. It is doubtful that there many 100%-polarized sources and so the “signal” is more typically a small fraction of the source flux. Thus, the source itself provides a substantial background, making continuum polarimetry even more difficult than narrow-line spectroscopy. X-ray polarimetry thus requires a dedicated mission that can, without programmatic pressures from other instruments/users, devote the integration time to perform *meaningful* measurements. The recently cancelled GEMS might have been such a mission. At least it was dedicated to polarimetry.

Performing *meaningful* measurements is not going to be easy. In part because of the long hiatus and lack of experience, there appears to be too much pressure to “sell” polarimetry missions by the number of sources for which one might answer the simple question is, or is not, the integrated and time averaged emission from the source polarized at some confidence level? This was a fine question for the 1970’s but, I maintain, it is not today. One simply doesn’t want to measure the time averaged polarization of the Crab’s pulsar, but one wants to know the polarization as a function of energy and pulse phase to compare, e.g. to optical and radio measurements which divide even the primary pulse into dozens of phase bins. Such observations can distinguish amongst competing theories for the pulsed emission. The Roadmap should define what meaningful experiments are. I will pose some suggestions.

Note that , because X-rays are usually believed originate in either non-thermal or highly aspherical situations we expect X-ray polarimetry to be much more important and rich in astrophysical information as opposed to the visible, where starlight often dominates the emission.

One has often dreamt about an instrument that does polarimetry whilst it does other things, and I will discuss this. Even in this case, one needs to realize that the observing time will be driven by the polarimetry, otherwise no useful polarization measurements will be made.

Finally, I will discuss some misconceptions that have appeared in the literature and at conferences which indicate to me that certain fundamental principles of polarimeter design and performance are *not* clearly understood. It is important for the Roadmap that we understand these principles and not advocate instruments that will not (or even worse cannot) accomplish the promised scientific return. I will discuss these principles.