High-resolution x-ray spectroscopy is a powerful tool for studying the evolving universe. The grating spectrometers on the XMM and Chandra satellites started a new era in x-ray astronomy, but there remains a need for instrumentation that can provide higher spectral resolution with high throughput in the Fe-K band (around 6 keV) and can enable imaging spectroscopy of extended sources, such as supernova remnants and galaxy clusters. The instrumentation needed is a broad-band imaging spectrometer – basically an x-ray camera that can distinguish tens of thousands of x-ray colors.

The potential benefits to astrophysics of using a low-temperature calorimeter to determine the energy of an incident x-ray photon via measurement of a small change in temperature was first articulated by S. H. Moseley over two decades ago. In the time since, technological progress has been steady, though full realization in an orbiting x-ray telescope is still awaited. A low-temperature calorimeter can be characterized by the type of thermometer it uses, and three types presently dominate the field. The first two types are temperature-sensitive resistors – semiconductors in the metal-insulator transition and superconductors operated in the superconducting-normal transition. The third type uses a paramagnetic thermometer. These types can be considered the three generations of x-ray calorimeters; by now each has demonstrated a resolving power of 2000 at 6 keV, but only a semiconductor calorimeter system has been developed to spaceflight readiness. The Soft X-ray Spectrometer on Astro-H, expected to launch in 2013, will use an array of silicon thermistors with HgTe x-ray absorbers that will operate at 50 mK. Both the semiconductor and superconductor calorimeters have been implemented in small arrays, kilo-pixel arrays of the superconducting calorimeters are just now being produced, and it is anticipated that much larger arrays will require the non-dissipative advantage of magnetic thermometers.

A quick review of the astrophysical motivation, the operating principles, some practical considerations, and the current state of the art will be followed by a discussion of the prospects for future development and deployment. Low-temperature calorimeter arrays are versatile instruments, and some applications outside of astrophysics will also be noted.