Taking Science by Swarm
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One important development that has occurred in ground-based astronomy during the past century is that of networked instruments. In many cases, the science enabled by a large number of relatively simple instruments distributed over a wide area can exceed that of a single large complex instrument. We are interested in the opportunities for such an approach in space – an approach we call a Science Swarm-Sat. The Swarm-Sat approach would be particularly beneficial for multi-messenger astronomy involving gravitational wave arrays, particle detectors, and electromagnetic instruments all operating in an integrated network. This would be to astrophysics what hyperspectral imaging is to Earth sciences.

One implementation of a Science Swarm-Sat array would be a three-dimensional, nominally periodic array. The spacecraft need not be identical, but would have a set of common functions and capabilities. Each satellite would have communications and ranging capability to not only nearest neighbors, but also next-nearest neighbors for redundancy, and precise position knowledge plus processing would be used instead of precision formation flying or station keeping. The network would have some distributed processing ability, and would be able to reconfigure itself for wide or narrow field of view operation using phased-array techniques. Such an array would be well suited for multi-messenger astronomy, where different elements of the same array could be used to survey the whole sky, rapidly reconfigure for narrow-beam operation upon a detection, and apply different types of detectors as needed for source localization and analysis of transients. For example, the array could detect an event with gravitational waves and use x-rays and radio to do immediate follow-up observations. The same array could process some of that data, and relay it through the array to the ground.

For example, each spacecraft would have:

- power source (solar array or RTG)
- high bandwidth optical communications combined with precision ranging
- low-noise, low-power long lifetime thrusters
- high precision clock
- high precision/low noise accelerometer
- other detectors as desired: X-ray, optical, UV, radio, etc