RX15-7

1. **Research Title:** Image Reconstruction and Modeling of Biological Materials
2. **Individual Sponsor:** List the AFRL research topic sponsor's contact information

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3. **Academic Area/Field and Education Level**

Electrical Engineering, Computer Science, Applied Mathematics, Materials Science and Engineering, Physics, Biology (MS or Ph.D. level)

4. **Objectives:** The need for recovery of useful content from images captured under less-than-ideal conditions pervades applications from RADAR to medical imaging to materials characterization. These real-world applications always have tradeoffs between data acquisition parameters, for example balancing the need for high signal to noise images (for maximizing interpretability) and fast acquisition times (for minimizing dose/power). Recently, efforts to improve the resolution and sensitivity of cryo-electron microscopy and low voltage electron imaging of materials have developed, however they are aimed primarily at detector hardware improvements, and the signal processing and noise modeling aspects have not been considered. The objective of this effort will be to generate novel signal processing software to reconstruct the data in an optimal way. Under this effort, iterative image modeling, point spread function deconvolution, denoising, and super-resolution will be explored as techniques to improve our understanding of biological and soft materials.
5. **Description:** Vast improvements over traditional noise filtering can be made if the noise is properly modeled based on the physics of the image formation process, however new algorithms need to be developed. For example, under single electron counting conditions where Gaussian electronic read noise can be eliminated, the noise can be modeled as purely Poisson. Modeling the interaction of the incident beam with the material, as well as the interaction of the exit wave with the detector, is critical for reconstruction under low dose restrictions. In conjunction with other high resolution characterization techniques, cryo-transmission electron microscopy and low voltage electron microscopy will be used for direct imaging on biomolecules adsorbed on surfaces. New algorithms will be developed for reconstruction of images under extreme cases of noise and lost signal, and will be generalizable to a wide array of applications. Iterative modeling of the 3D biomolecular structure will be related to mechanical, electrical, redox, catalytic and binding properties. This research will have near term impact to biological materials research, soft matter materials development, and other areas where imaging dose is limited due to damage, limited view, high frame rate acquisition, or other constraints.

6. **Research Classification/Restrictions:** This research has no ITAR restrictions.
7. **Eligible Research Institutions:** Indicate to what organizations this topic should be provided

**DAGSI** (Wright State University, AFIT, Ohio State University, University of Dayton, Miami University, Ohio University, University of Cincinnati) NOTE: Topics submitted to DAGSI must be approved for public release. Need PA Approval #88ABW-2014-2951