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Discrimination and classification of bio-aerosol particles using optical spectroscopy and scattering

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For more than a decade now, there has been significant emphasis for development of sensors of agent aerosols, especially for biological warfare (BW) agents. During this period, the Naval Research Laboratory (NRL) and other labs have explored the application of optical and spectroscopic methods relevant to biological composition discrimination to aerosol particle characterization. I will first briefly attempt to establish the connection between sensor performance metrics which are statistically determined, and aerosol particle measurements through the use of computational models, and also describe the challenge of ambient background characterization that would be needed to establish more reliable and deterministic sensor performance predictions. Greater attention will then be devoted to a discussion of basic particle properties and their measurement. The NRL effort has adopted an approach based on direct measurements on individual particles, principally of elastic scatter and laser-induced fluorescence (LIF), rather than populations of particles. The development of a LIF instrument using two sequential excitation wavelengths to detect fluorescence in discrete spectral bands will be described. Using this instrument, spectral characteristics of particles from a variety of biological materials including BW agent surrogates, as well as other "calibration" particles and some known ambient air constituents will be discussed in terms of the dependence of optical signatures on aerosol particle composition, size and incident laser fluence. Comparison of scattering and emission measurements from particles composed of widely different taxa, as well as from similar species under different growth conditions highlight the difficulties of establishing ground truth for complex biological material compositions. One aspect that is anticipated to provide greater insight to this type of particle classification capability is the development of a fundamental computational model of fluorescent emission for a particle of known composition but arbitrary size and shape. Finally if time permits, I will review the recent development and use of a 40 MHz mode-locked 524 nm laser source to evaluate the utility of sub-picosecond excitation of fluorescence with 2-photon absorption in biological aerosols.