Frequency-Domain Reconstruction of Spectral Refractive Index and Particle Size Distribution

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The spectral complex refractive indices ($m = n - ik$) and particle size distribution (PSD) are crucial properties that need to be measured in applications like environmental monitoring, remote sensing, and biofuel production, etc. In the present work, an inverse method is proposed that allows m and PSD to be retrieved simultaneously by measuring the amplitude and phase angles of reflectance and transmittance signals. An improved quantum-behaved particle swarm optimization algorithm is employed as the inverse problem algorithm. It is found that the amplitude of reflectance and transmittance signals of 1D particulate system under illumination of frequency-domain pulse lasers are highly sensitive to m and relatively insensitive to PSD. On the other hand, the phase angles of reflectance and transmittance signals are more sensitive to PSD. Therefore, under the condition that both m and PSD are unknown, m can be accurately obtained by measuring the amplitude of reflectance and transmittance. Then, the PSD of the particulate system can be estimated using the measured phase angles of reflectance and transmittance with a known m. To further improve the accuracy of obtained m and PSD, the reflectance and transmittance signals of the particulate system under multiple frequencies of the light source are utilized.