Wavelength Dependence of Backscatter

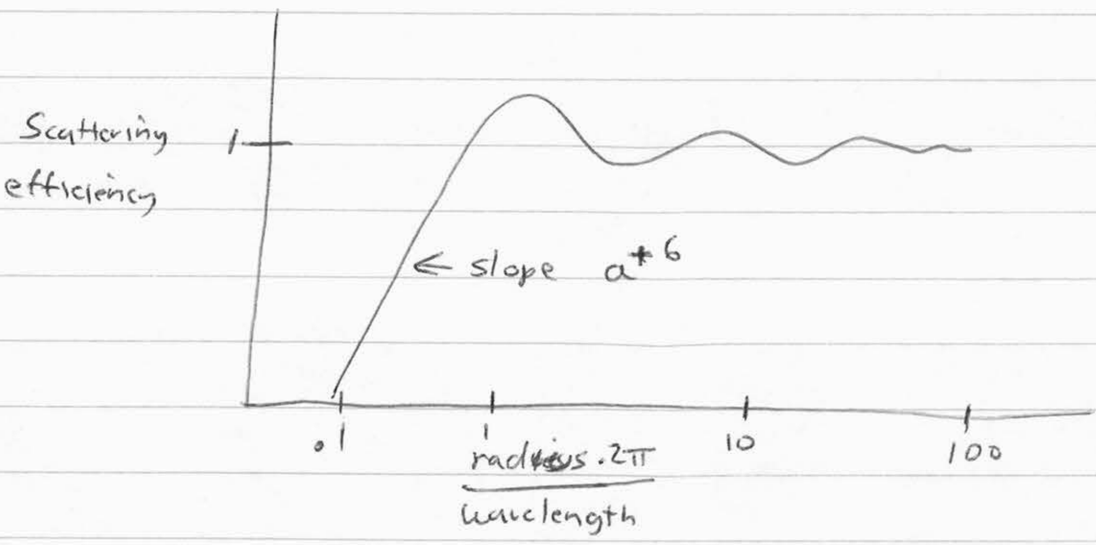
We often state that radar backscatter is dominated by structures similar in size to the radar wavelength. Thus use of multiple-wavelength radars permits investigation of a range of surface scatterer sizes.

The coupling between wavelength and scatterer size is self-evident for Bragg scatter, which matches the carrier λ to a particular Fourier component of the surface. But how does this relation evidence itself for other models and mechanisms?

Let's examine what happens in the case of discrete scatterers of various sizes.

Extinction / Scattering Cross-Section curves

The following curve relates scattering efficiency to particle size as a function of radius, in wavelengths:

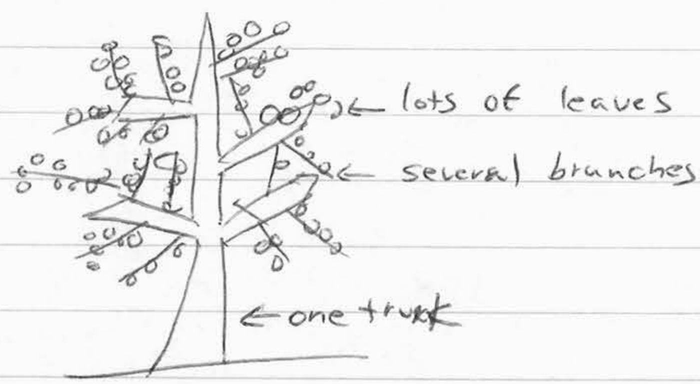


We interpret this curve as implying that the effective cross-section of a particle is equal to its physical cross-section if the particle is comparable to a wavelength in size or larger, but falls off very steeply for smaller particles. In other words, the radar instrument is not very sensitive to sub-wavelength size particles.

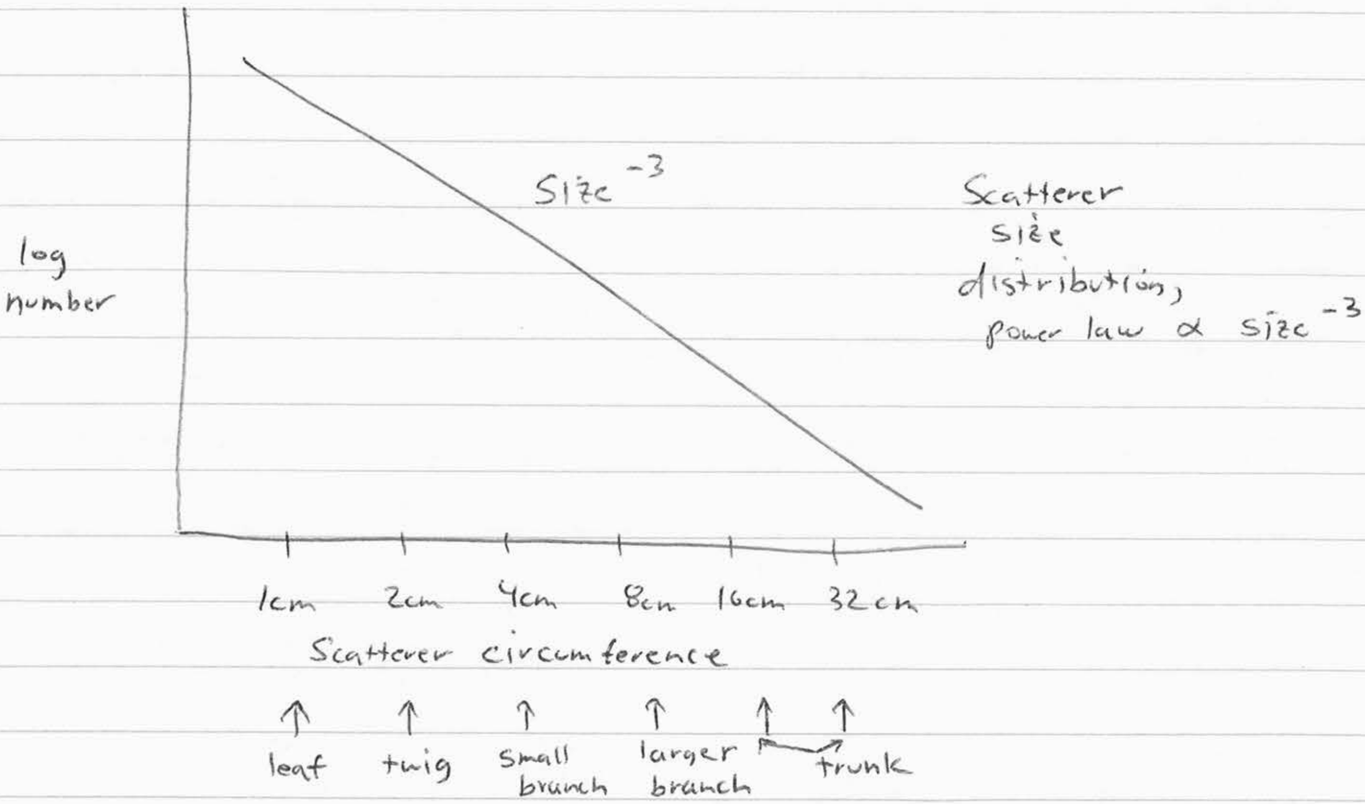
Incidentally, this is why the radar easily "sees" through clouds. The ice and water droplets in a cloud are much smaller than radar wavelengths, but are large compared to optical wavelengths. Thus the microwave radiation readily penetrates.

Scatterer size distribution

Now consider imaging a tree, which consists of a trunk, a few large limbs, many smaller branches and twigs, and a host of leaves.



Construct a table giving the number of each size scatterer and also the total cross-section of each, as well as the cross section normalized by scattering efficiency. Let's assume the number of scatterers of a given size obeys a power law distribution, falling off as $size^{-3}$, which is typical for some plants and many surface scatterer distributions.



Scatterer	Number on tree	Physical cross section	Effective cross-section $\lambda = 2$ cm		Effective cross-section, $\lambda = 8$ cm	
Leaves	4096	$\frac{1024}{\pi}$	$\frac{32}{\pi}$		$\frac{1}{32\pi}$	
Twigs	512	$\frac{512}{\pi}$	$\frac{512}{\pi}$	← dominant	$\frac{1}{2\pi}$	
Small branches	64	$\frac{256}{\pi}$	$\frac{256}{\pi}$		$\frac{8}{\pi}$	
Larger branches	8	$\frac{128}{\pi}$	$\frac{128}{\pi}$		$\frac{128}{\pi}$	← dominant
Trunk	1	$\frac{64}{\pi}$	$\frac{64}{\pi}$		$\frac{64}{\pi}$	

Thus the return is dominated by λ-size scatterers!