Two-Body Multiple Scattering

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To achieve improved target discrimination and identification has been the driving force behind the development of high-resolution radar systems. A method of target identification with wideband radar data is to form a Synthetic Aperture Radar (SAR) or an Inverse Synthetic Aperture Radar (ISAR) image of the target by spatially isolating the individual scattering sources. However, to design better radar signal processor requires a complete understanding of the interactions between isolated scattering sources.

With the exception of low-frequency regime, radar returns can be modeled as a combination of many scattering components. These components are broadly classified into those that can be associated with the direct returns from isolated portions of the target and those that can be associated with interactions between different scattering sources on the target (or targets). Specular returns and scattering from surface discontinuities such as edges, corners, and tips can be associated with direct returns, whereas contributions from creeping waves, traveling waves, cavities, and other multiple diffraction phenomena would be associated with higher-order scatterings. These higher-order scattering components are actual physical entities that collectively contribute to total response from a target and not mere mathematical concepts. Significant contributions due to higher-order scattering can complicate the process of deducing a real physical image. Whereas the direct returns are associated with scattering sources that are constrained to their exact physical locations, higher-order scatterings produce returns that appear at nonexistent physical locations or totally outside the target boundary. Therefore, unless taken into account, returns due to coupling between scattering centers can result in distorted image being formed and/or an apparent size that is greater than the actual target dimensions. As a result, a thorough understanding of the characteristics of higher-order scatterings is critical to the eventual resolution of this problem.

The multiple scattering of electromagnetic waves by several simple two-body targets was studied in terms of their sub-nanosecond pulse returns. The wideband target responses were analyzed through use of an asymptotic solution to a generic two-body scattering formulation, and the computed results will be discussed with emphasis towards the coupling phenomenon. These coupling components between bodies were isolated experimentally using a coherent X-band high-resolution radar system, and the data were in good general agreement with the analytical solutions. It is shown that multiple scatterings can contribute significantly to the total radar cross-section even when the scattering sources are separated by many wavelengths. Therefore, when a target identification scheme based on forming a spatial image of the target is used, appropriate measures must be incorporated to account for image distortion due to higher-order scatterings. For the past twenty years, the availability of numerous high-quality wideband instrumentation radars has provided a powerful diagnostic tool for the isolation and identification of significant scattering sources and for the verification and the refinement of theoretical scattering models at microwave frequencies.