# Seismic interferometry for passive and exploration data

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It has been shown by many researchers in geophysics, ultrasonics and underwater acoustics that the cross-correlation of acoustic wave fields recorded by two different receivers yields the response at one of the receiver positions as if there was a source at the other [Claerbout (1968), Duvall et al. (1993), Rickett and Claerbout (1999), Weaver and Lobkis (2001), Campillo and Paul (2003), Roux et al. (2004), Shapiro et al. (2005)]. Various theories have been developed to explain this phenomenon, ranging from diffusion theory for enclosures [Lobkis and Weaver(2001), Weaver and Lobkis (2002)], multiple scattering theory and stationary phase theory for random media [van Tiggelen (2003), Malcolm et al. (2004), Snieder (2004)] and reciprocity theory for deterministic and random media (non-moving or moving) [Wapenaar et al. (2002-2006), Weaver and Lobkis (2004), van Manen et al. (2005)].

The derivations based on reciprocity theory yield exact representations of Green's functions in arbitrary inhomogeneous lossless media. Hence, the reconstructed Green's functions do not only contain the direct wave field between the two receiver points but also all primary and multiply scattered waves. This requires, however, that the two receivers are surrounded by sources on an arbitrarily shaped closed surface. In reality this condition is seldom fulfilled. In this presentation we discuss two distinct situations for which the surface containing the sources is not closed and we discuss the conditions that are needed in order to reconstruct the exact Green's function, including the internal multiples. The first situation we consider corresponds to passive seismic data, for which we usually assume a distribution of natural noise sources along an open surface in the Earth's subsurface. The free surface acts as a mirror, which obviates the need of having sources on a closed surface. This situation has been extensively discussed in the literature, but we include it for completeness. The second situation is that of seismic exploration, with sources at the Earth's surface only. Seismic interferometry for exploration data has been extensively discussed by Schuster et al. (2001-2006) and Bakulin and Calvert (2004). Impressive results have been obtained for primaries and first order free surface multiples. However, since the surface with sources is not closed, internal multiples are not correctly handled by these methods. Bakulin and Calvert (2006) propose to replace the correlation by a deconvolution process, which acts as a dereverberation filter. This approach partly solves the internal multiple problem but it does not account, for example, for peg-leg multiples. In this paper we reconsider seismic interferometry for exploration data and show how, in theory, all internal multiples can be correctly handled.