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Shear wave splitting measurements from deep moonquakes

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Shear wave splitting (SWS) measurements are part of the standard seismic analysis toolbox, as they reflect the degree of anisotropy along an earthquake's raypath. Anisotropy is caused by a range of geological processes, for example bulk fracturing in rocks, rock layering, tectonic stresses, and grain fabric direction. For the first time, we take this technique off-world and make successful SWS measurements on seismic data collected during the Apollo Moon missions, as part of the Apollo Passive Seismic Experiment [1].

We began with 35 of the highest quality "deep moonquakes", which have favorably-oriented raypaths originating deep within the lunar mantle, at depths of about 800–1000 km. Objective SWS measurements were made automatically using MFAST software [2], which is based on the Silver and Chan (1991) method [3]. Out of 35 deep moonquakes, and up to 118 total measurements across all four Apollo stations, 28 measurements were successfully made by MFAST on Apollo clusters A1, A6, A7, A22 and A40. Most of the successful measurements came from the A1 cluster. We observe a repeated waveform complication which is producing some transversely polarized S wave energy which can be interpreted as shear wave splitting from the perspective of the Apollo 16 seismometer.

Presently, we are modifying the MFAST codes to work with the Wolf and Silver (1998) [4] technique, to look for clear evidence of patterns in the measurements. For example, if SWS measurements are consistent between deep moonquake clusters at the same station, it's evidence for receiver side anisotropy. If SWS measurements are consistent between stations, it's evidence for source side anisotropy. An obvious pattern like this would be convincing as it is an internally consistent result, and one that we would interpret as prima facie evidence of shear wave splitting.

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