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Analysis of induced birefringence in host-inclusion mineral systems: a Raman spectroscopy approach

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Anomalous birefringence in host-inclusion mineral systems can develop as a response of the contrast in the elastic properties between the two crystals. Indeed, if the inclusion is “pressurized” it may transmit to the adjacent host a stress component able to locally deform its crystal structure. Key evidence of this is the development of induced birefringent haloes of a cubic host surrounding pressurized inclusions. From an optical point of view, this phenomenon (the piezo-optic effect) has been widely described (e.g. Howell, 2012) since it represents the starting point for selecting suitable mineral inclusions for elastic geo-barometry. Nevertheless, while the strain state of the inclusion has been addressed in detail (e.g. Murri et al., 2018), that of the surrounding host is still poorly understood. Our experimental results suggest that Raman spectra collected on garnet with birefringent haloes around pressurized inclusions, such as zircon and quartz, display anomalous Raman activity as well. In particular, the totally symmetric vibrations show a tiny but well-resolved scattering activity in cross-polarized spectra that, for cubic crystals, is usually forbidden as well as the birefringence under cross-polarized light. Then, we have seen that the ratio between the crossed and parallel polarized Raman intensity of such modes could represent a reliable tool in quantifying the amount of strain across the host crystal. Finally, this experimental approach coupled with theoretical considerations allowed us to determine the stress-induced symmetry of the host and then its strain state with respect to a stress-free domain. We therefore propose this as a complementary approach for investigating anomalous birefringence in crystals.

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