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Identifying representative shapes in fields of temperature spectra in vacillating baroclinic waves

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With the aim to identify the importance of local fluctuations in a large-scale baroclinic wave for the transition from regular waves via structural vacillation to turbulence, a spectral analysis of time series of infrared thermography images in the rotating baroclinic annulus are presented.

After transforming the images to a frame of reference moving with the main baroclinic wave and then removing the time-averaged mean wave from the temperature fields, power spectra for the time series of the residual temperature fluctuations at each point in a regular radius-azimuth grid were calculated. To identify representative spectral features, the spectra were reduced to a set of spectral shapes using a Principal Component / EOF Analysis such that they explained 99% of the variance. The set of Principal Component at each grid point were then grouped in a cluster analysis.

The key findings were that the number of Principal Components increased gradually as the Grashof number was increased, that initial low-frequency variability was associated with the location where the cold jet interacted with the Stewartson layers on the warm outer boundary and the associated formation of the warm gyre extending from the warm boundary layer into the fluid interior. The final observation was that the regular steady and vacillating waves had a well defined spectral slope varying with Grashof number throughout the fluid alongside the localised low-frequency peaks. In contrast, the less regular flows showed little difference in the low-frequency behaviour across different parts of the fluid while the spectral slopes showed clear spatial variation.