Scroll Wave Interactions

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Scroll waves are the three-dimensional counterparts of spiral waves occurring in excitable media. Single scroll waves may undergo a series of instabilities that play an important role in the formation of cardiac arrhythmias, like ventricular tachycardia and fibrillation. While some experimental effort has been devoted to the study of the dynamics of single scroll waves, the interaction of scroll waves has so far received much less attention.

We present an experimental study of the interaction of a pair of scroll waves with each other. The scroll waves were created in a Belousov-Zhabotinsky reaction medium and observed by optical tomography with a parallel beam technique. We studied scroll waves whose filaments were parallel to each other and oriented along the vertical axis of the reaction cylinder [1]. The dynamics of such a pair of scroll waves was found to depend on the distance between the filaments: When the distance d between the two filaments was shorter than the wavelength λ of the scroll wave (but larger than the extension of a spiral core), then the filaments displaced each other, until the inter-filament distance d became comparable to the wavelength (i.e. until $d \sim \lambda$). Once $d \sim \lambda$, the scroll waves rotated without being disturbed by each other.

On the other hand, in the presence of fluctuations, the rotation frequencies of the two scroll waves may become different due to spontaneous symmetry-breaking. In this case, the scroll wave with a higher rotation frequency displaced that with a higher rotation frequency, until the latter was eventually ousted or annihilated.

When the distance between the two filaments was shorter than the spiral core radius, then two behaviours were observed: Co-rotating scroll waves (i.e. scrolls that presented the same sense of rotation) always repelled each other. By contrast, counter-rotating scroll waves may suffer a “crossover collision” [2], leading to a rupture and a subsequent reconnection of the filaments. Each reconnected filaments consisted of parts that originated from the two original filaments. The conditions for rupture and reconnection of filaments will be discussed.

1. D. Kupitz, M. J. B. Hauser, *Phys. Rev. E*, submitted.

2. B. Fiedler and R. M. Mantel, *Documenta Math.*, **5**, 695 (2000).