Pattern formation of buble periodically emerging at a liquid free surface

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Patterns formed by bubbles of centimeter scale on the free surface of a viscous liquid are investigated. The liquid is contained in a vertical cylindrical tank. Bubbles are released into the liquid periodically by continuous gas injection through an orifice at the center of the tank bottom. These bubbles ascend vertically in a regular chain and emerge at the surface. Their radial emission due to the interaction with each other at the emergence and to radial surface flow generated by their ascending motion leads to the formation of a variety of patterns. At low flow rate of the gas injection, successive emerging bubbles are emitted with a constant angular shift equal to π. Two opposed arms of bubbles are then exhibited on the surface. Beyond a critical flow rate, the angular shift departs from π through a supercritical bifurcation and decreases with the flow rate increasing. Bubbles on the surface form a variety of patterns with different numbers of spiral or straight arms. For revealing the mechanism of this pattern formation, measurements of bubble motion and liquid flow are performed, respectively, by image processing and by the PIV technique. We analyze these results with using the tools and concepts of the study of leaf arrangement in botany (phyllotaxis). Close similarities between these two pattern formations will be presented.