What is “fluid”?, a brain-stimulative experimental subject based on soft-gel suspension dynamics

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In the education of university freshman course reconsideration of the fundamental concepts is a good chance for a self-motivating start of learning. In the high school education the fundamental concepts such as in physics are usually given over head without enough attentions. A good example is the concept of mass. It is vaguely defined in high school level and the deep insight on the concept of mass leads to the modern physics. In the freshman course education we should provide a chance in the classroom for regarding the fundamental concepts with suspicions.
In this presentation we propose dynamics of soft gel suspension as a stimulative and intuitive experimental subject which can be used in the class room to reconsider the concept of fluid.
Let’s consider at first a simple case of a sphere falling through viscous fluid. By comparing force balance between viscous force and buoyancy the falling velocity is given as a function of viscosity and size of the sphere. This can be demonstrated easily by using a steel sphere and sugar syrup in a transparent acrylic tube. Measurement of the position of falling sphere easily leads to the Stokes’s formula.
After learning fluid dynamics of falling sphere through viscous fluid based on conventional textbooks we replace the fluid with soft-gel dense suspension. Soft gel is easily prepared by using SAP(Super Absorbent Polymer, which is available as “Mizu no Orusuban” at 100-yen shop). SAP absorbs water and expands by 100-200 times. By adding adequate amount of water dense suspension of soft gel is prepared. To control the grain size of the suspension SAP grains are selected from sieved fractions(for example, 90-100micron for the final gel size of less than1mm and 425 to 500 micron for several mm). By conducting similar falling sphere experiment three kinds of interesting behaviors can be identified in terms of changing the size of sphere(Sgreva et al, 2019,2020). When the size is larger enough than the size of gel the sphere falls as similar to viscous fluid. When it is smaller than the size of gel it never falls. The soft gel suspension behaves as a yield stress fluid depending on the scale. At the intermediate size breathtaking behavior can be observed. Falling speed is not homogenous and the sphere sometimes stops for a while, then moves again. Not only the stop & go behavior it sometimes sways away horizontally. We name this regime as a meditated fall. By inspection of the motion of the sphere closely through laser illumination it is shown the sphere explores available routes to move among the gels and gels slowly deform and migrate to give a way to the sphere. This process seems to be controlled by the permeability. Based on the observations about the behaviors of sphere in the classroom we can discuss what is fluid and what is solid and the nature of viscosity. Detailed syllabus will be shown in the presentation.
Reference:
N.Sgreva et al EGU 2019 #7870 Scale-dependent magma rheology: insights from laboratory experiments
N.Sgreva et al EGU 2020 #9113 Probing the characteristics of mush-magma transition: insights from laboratory experiments

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