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Shapes of Molecular Aggregates Associated with a Critical Point of Solution

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RCEU22-CH-JKB-01 Shapes of Molecular Aggregates Associated with a Critical Point of Solution

1.Project Description

The concept of critical point universality is known to govern the special effects that occur in the case of phase separations such as the liquid to vapor transition in pure fluids, the normal conductor to superconductor transition in superconducting materials, and the order to disorder transition in substitutional alloys. In the case of all of these various phase transitions, the material passes from an organized state to a disorganized state. The passage from one state to the other involves the formation of a continuous range of aggregates of various sizes and shapes starting with complete organization on the molecular scale and ending in complete disorganization on the molecular scale. Nonetheless, all that is certain about the shapes and sizes of the intermediate structures is that in cases where the material is optically transparent, the aggregates are able to scatter visible light, implying that they are of the same size as the wavelength of the light, which ranges from 400 nm to 700 nm.

The light scattering effect is particularly evident in the case of a binary liquid mixture having a critical point of solution. At the critical point of solution, the mixture is sufficiently cloudy that it fails to transmit light to any significant degree. Recently, we have shown, however, that in the case of two liquids having closely matched refractive indices, the cloudiness is completely suppressed, and the mixture becomes transparent. This transparency allows us to study the transmission of polarized light by the mixtures. If the direction of polarization of the light is *rotated* through any angle after passing through the liquid, we will know that the mysterious critical point aggregates consist of an unequal mixture of shapes having right handed symmetry and shapes having left handed symmetry. If the direction of polarization is *unaltered* upon passage through the liquid mixture, we can conclude either that (1) the right and left handed aggregates occur in equal proportions, or (2) the aggregates are symmetric and are characterized by rotational symmetry and/or reflection symmetry. In the case of either (1) or (2), our results will provide a challenge to physicists who model the sizes and shapes of critical point aggregates using computer simulation.

2.Student Duties, Contributions, Outcomes

a. Specific Duties: Our 2022 student will set up a thermostat consisting of water bath, stirrer, temperature controller, and thermometer to determine the temperature. The student will prepare mixtures of pairs of liquids having carefully matched refractive indices. Using the water bath to maintain the temperature at the critical value for the mixture, the student will then determine the angle of rotation of the polarized light passed by each sample. The student will use a polarimeter, which we have constructed in our laboratory in the Optics Building.

b. Tangible Contributions: The student will learn how to correct and adjust temperature controlled optical apparatus so as to optimize the accuracy and precision of a physical measurement.

c. Specific Outcomes: The student will learn to appreciate how to design and carry out an experiment that serves not only as a challenge to current thinking but also as a guide to the development of new concepts by both experimenters and theorists.

3. Student Selection Criteria

Rising juniors or seniors with majors in Chemistry, Chemical Engineering, or Physics are encouraged to apply.

4. Student Mentorship

The student will become a full member of our research group, which consists of three graduate students and two other undergraduates. This group meets every one to two weeks in order to discuss recent research results and advances in the theory. The students give power point presentations when they have something new to report. In many cases, the undergraduates learn more from working with the graduate students in the laboratory than they do listening to me talk at these meetings! Nonetheless, I am in my university office every day during the summers in order to consult with students on a walk-in basis. As a rule, the REU student becomes a coauthor on one or more of our published papers.