Flowing Liquid Crystal Simulating the Schwarzschild Space-time

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A way to calculate the path of propagating light inside a liquid crystal is using Fermat's Principle. This says that the light traveling between the points A and B will travel the track that minimizes an integral which depends on the refractive index at each point. In the field of Riemannian geometry, calculating the curve between points A and B that minimizes the line element *ds* of the manifold in study (geodesic) is equivalent to finding the light path under these boundary conditions. As seen in [1,2], this allows us to interpret the light path calculated by Fermat's Principle as a geodesic of an effective metric. When one uses this similarity for the light propagation in calamitic liquid crystals in nematic phase with disclination-like defects [2], it is observed that the properties of the metric depend on the values of the ordinary and extraordinary refractive indexes of the molecule of liquid crystal in use. At this point, we remind that the approximate values of these refractive indexes of the molecule are dependent on the temperature [3] and, thus, in agreement with Haller's approach [4], these indexes are dependent on the scalar order parameter. In order to control this order parameter, we used the theory of Beris-Edwards [5], that demonstrates that the order parameter of materials with internal microstructure (for instance, nematic liquid crystals) depends on the local speed gradient in these materials. We obtain a profile of radial speed that simulates the equatorial section of the Schwarzschild metric (this special metric describes the outside space-time of planets and all spherically symmetric, no charged, no rotating, bodies).

References

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