Optics and chaos in two-dimensional curved space

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Investigation of physics on two-dimensional curved surface has significant meaning in study of general relativity. We have revisited several physical phenomena in a special type of two-dimensional curved space, surface of revolution, including:

1. Wolf effect. Wolf effect refers to a spectral shift of polychromatic light during its propagation, which results from the fluctuating (or correlation) nature of light sources. We have revealed the influence of space curvature on the Wolf effect both on surface with constant Gaussian curvature and on arbitrary surfaces of revolution.

2. Gouy phase. By generalizing angular spectrum method on curved surface, we have studied the property of Gouy phase, which is an additional phase shift of a converging, monochromatic beam when propagating through its focus, on curved space. We have also discovered an additional phase shift induced by spatial curvature.

3. Chaos. By applying the method of transformation optics, we are able to transfer the problem of chaos on curved surface to that on a plane with varying refractive index. We have studied classical chaos properties, including Poincare surface of section and Lyapunov exponent, in such a dynamical billiard with an eccentrical circular hole.