INVESTIGATION OF OPTICAL INTERFERENCE EFFECTS IN THE GENERALIZED EIKONAL FORMALISM

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Abstrak

Dalam kajian yang telah dijalankan[1-5], persamaan eikonal am dan persamaan keselanjaran telah ditunjukkan mampu untuk menjelaskan fenomena gelombang yang tidak boleh dijelaskan melalui optik geometri. Persamaan eikonal am bersandaran masa yang diperolehi dari persamaan gelombang Maxwell bersandaran masa, mampu menunjukkan kesan penyebaran dan kesan soliton. Kaedah ini kemudiannya dilanjutkan bagi mengkaji kesan belauan, swafokus bagi bahantara linear dan taklinear dengan menggunakan gelombang pegun. Bagi beberapa kes yang tidak mempunyai penyelesaian analitik, persamaan eikonal am dan persamaan keselanjaran diselesaikan melalui kaedah berangka. Keputusan yang diperolehi bersetuju dengan keputusan dari penyelesaian pengamilan Fresnel-Kirchhoff. Persoalan yang timbul kini merupakan samada persamaan eikonal am, sebagai persamaan tak linear, boleh menunjukkan kesan linear iaitu superposisi dua bim.

Kajian ini membuktikan bahawa persamaan eikonal am adalah konsisten dengan prinsip superposisi dan membenarkan kesan linear. Terlebih dahulu, kajian ini menunjukkan secara teori bahawa formalism ini mematuhi prisip superposisi. Kemudiannya, kajian ini menunjukkan melalui kaedah berangka bahawa formalism ini berupaya memberikan kesan superposisi dua gelombang, dengan ini membuktikan kesan interferens. Untuk tujuan ini, satu kaedah berangka dikembangkan bagi menyelesaikan persamaan eikonal am dan persamaan keselanjaran. Kaedah berangka yang digunakan adalah berdasarkan skema 'forward time central space (FTCS)' yang mempunyai

masalah ketakstabilan. Masalah ini diatasi dengan menggunakan kaedah implisit keatas skema ini. Kaedah implisit ini berjaya menstabilkan skema FTCS dan juga meningkatkan kejituan skema pada keseluruhannya. Keputusan yang diperolehi melalui skema ini bersetuju dengan keputusan yang diperolehi dari pengamilan Fresnel dengan magnitud ralat relatif 10^{-5} pada 1 meter dari asalan. Dengan menggunakan skema ini, kesan gelombang belauan dan interferens bagi dua dan lebih bim boleh dikesan dengan mengikuti lintasan sinaran bim. Keputusan bagi kesan gelombang yang didapati melalui formalism eikonal am bertepatan dengan keputusan pangamilan Fresnel. Dengan itu, formalism eikonal am telah disahkan, secara teori dan melalui kaedah berangka, memuaskan prinsip superposisi serta menggambarkan kesan interferens oleh dua atau lebih gelombang cahaya.

Abstract

In recent studies[1-5], the generalized eikonal equation and the equation of continuity had been shown able to describe wave phenomena, which cannot be obtained by simple geometrical optics. The time dependent generalized eikonal equation, derived from the time dependent Maxwell wave equation, is able to describe dispersion and soliton effects. This method was extended to include diffraction, self-trapping and self-focussing in linear and non-linear media for stationary waves. For cases that have no analytical solution, the generalized eikonal equation and the equation of continuity are solved numerically. The solutions are in good agreement with the solutions obtained from the Fresnel-Kirchhoff integral. The question remains whether the generalized eikonal equation, as a non-linear equation, can be used to show a linear effect, that is, the linear superposition of two beams.

In this study, it will be shown that the generalized eikonal formalism self consistently satisfies the superposition principle and allows interference effects. First, it will be shown, theoretically, to comply with the superposition principle. Numerically, it will also be shown that the formalism satisfies the linear superposition of two beams, thus giving interference effects. For this purpose, a general numerical program was developed to solve the generalized eikonal equation and the equation of continuity. The forward time centred space (FTCS) scheme used had a stability problem that was overcome by the application of an implicit method to the scheme. The implicit method stabilizes the FTCS scheme and shows an improvement in accuracy. The results obtained by this scheme

agree with those obtained by the numerically solved Fresnel integral with a relative error of the order of 10^{-5} at 1 meter away from the origin. By using this scheme, point by point ray tracing of wave effects in the diffraction and interference of two and more beams were carried out. These results closely match those calculated by the Fresnel integral. The generalized eikonal formalism has thus been verified both theoretically and numerically to satisfy the superposition principle enabling the interference of two or more light waves to be described.

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