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Polarization effects of algebraically special Maxwell field in the Kerr space-time

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For obtaining polarization effects in the Kerr space-time we have used algebraically special approach for Maxwell equations [1].
As a consequence, in Kinnersley tetrad Maxwell field is described only by one extremal component φ_2, and the Maxwell equations have closed-form solution [2]:

$\varphi_2 = C\frac{e^{i\omega(t-\tilde{r})+im\phi}}{\sin\theta(r-ia\cos\theta)}e^{-a\omega\cos\theta}\left(\frac{1-\cos\theta}{\sin\theta}\right)^m,$

where $t>0$, $r_+<r<\infty$, $0<\theta<\pi$, $0\le\phi<2\pi$, $\tilde{r}=r+M\ln\Delta+\frac{M^2}{\sqrt{M^2-a^2}}\ln\left(\frac{r-r_+}{r-r_-}\right)+\frac{am}{2\omega\sqrt{M^2-a^2}}\ln\left(\frac{r-r_+}{r-r_-}\right)$, $\omega\in\mathbb{R}$ is a frequency of the wave, $m\in\mathbb{Z}$ is an azimuthal number, M is a mass of gravitating body, a is an angular momentum per unit mass ($a<M$), $\Delta=r^2-2Mr+a^2$, $r_+=M+\sqrt{M^2-a^2}$, $r_-=M-\sqrt{M^2-a^2}$, $C=C_m(\omega)$ is a complex constant.

From the above solution for outgoing waves, we have obtained formulas for Stokes parameters, ellipticity angle and polarization angle, and gravitational analog of Faraday effect. There are distinguished two polarization effects in Kerr field. The first one is the rotation of the plane of polarization (RPP), and the second is the influence of angular momentum of rotating body on an amplitude of right or left circularly polarized waves, discovered for low and high frequencies in [3,4]. Obtained in our approach results confirm the formula of Gnedin and Dymnikova [5] for the RPP, dispersion of the RPP is absent. The influence of angular momentum on amplitude is established by a closed-form expression in the full range of frequencies.

References

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