

## Radiation of Twisted Electromagnetic Waves from a Multigap Loop Antenna with Phased Excitation in a Magnetoplasma

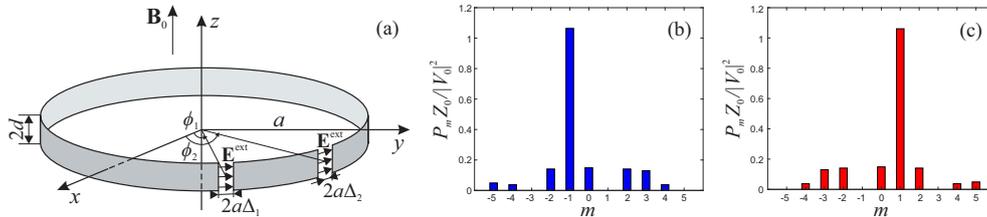
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Twisted waves are those that have a helical phase front which is described by the relation  $\omega t - m\phi - hz = \text{const}$ , where  $\phi$  and  $z$  are the azimuthal and axial cylindrical coordinates, respectively,  $t$  is the time,  $\omega$  is the angular frequency,  $m$  is the azimuthal index ( $m = 0, \pm 1, \dots$ ), and  $h$  is the axial wave number. The interest in such waves is related to the fact that they carry orbital angular momentum, which can be used for some promising applications [1].

In this work, we discuss the excitation of such waves by a multigap loop antenna immersed in a magnetoplasma with an external magnetic field  $\mathbf{B}_0$  aligned with the  $z$  axis, as shown in Fig. 1(a). The azimuthal current with the surface density  $I(\phi, z)$  is excited in the strip conductor of the considered antenna by an external electric field  $\mathbf{E}^{\text{ext}}$ , which is produced in the feeding gaps by the voltages  $V_k = |V_k| \exp(i\psi_k)$ , where  $|V_k|$  and  $\psi_k$  are the magnitude and phase of the voltage supplied across the  $k$ th gap with its angular half-width  $\Delta_k$ , respectively. To determine the unknown antenna current, we expand its surface density into a Fourier series over the azimuthal coordinate and formulate the integral equations for the expansion coefficients  $\mathcal{J}_m(z)$  of such a series. To this end, we derive a representation of the antenna-excited field using the approach of [2] and then satisfy the boundary conditions for the tangential components of the total electric field on the surface of the perfectly conducting strip. Upon finding the solutions of the integral equations for the quantities  $\mathcal{J}_m(z)$  by the method described in [3], we calculate the current distribution and the total radiated power of the antenna. It turns out that this power is reduced to the sum of the partial powers  $P_m$ . Each quantity  $P_m$  describes the power going to twisted waves with the azimuthal index  $m$  and is determined by the  $m$ th azimuthal harmonic  $\mathcal{J}_m(z)$  of the surface current density. We show that by choosing the magnitudes and phases of the excitation voltages, it is possible to maximize the desired partial power, as is seen in Figs. 1(b) and 1(c) that are plotted for a two-gap antenna in the case  $|V_{1,2}| = |V_0|$  under ionospheric plasma conditions. Note that selective excitation of twisted waves with reasonably greater azimuthal indices  $m$  can further be achieved by increasing the number of the gaps and appropriately choosing the phases of the feeding voltages.



**Figure 1.** Geometry (a) and the normalized partial radiated powers  $P_m$  of a two-gap antenna with the radius  $a = 5$  m,  $\Delta_{1,2} = 0.01$  rad,  $d = 1$  cm, and  $\phi_2 - \phi_1 = \pi/2$  at the frequency  $\omega = 1.9 \times 10^5$  s<sup>-1</sup> ( $Z_0$  is the free-space impedance) for  $|\mathbf{B}_0| = 0.5$  G and a plasma density of  $10^6$  cm<sup>-3</sup> in the cases  $\psi_2 - \psi_1 = \pi/2$  (b) and  $\psi_2 - \psi_1 = -\pi/2$  (c).

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## References

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