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Electrodynamic mechanism for deployment and stabilization of thin film structures in space

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Theoretical modeling of electrodynamic mechanism for deployment and stabilization of thin film structures in space is considered. It is shown that such mechanism can be realized providing the zero integral magnetic moment of the system. Calculation of the strain tensor in thin plate with superposition of the conductors in a form of N concentric circles with radius r_i was carried out. The largest radius of circular current coincides with the plate radius $r_N = R$. Direct currents I_i flowing in these conductors generate the magnetic field $\boldsymbol{B}$ in ambient space. The exact solutions are found for surface density of forces acting upon the plate by the superposition of thin concentric circular currents taking into consideration the effects of own magnetic field on the conductor. The task of selection of optimal parameters for the current system providing the deployment and stabilization of the film structure with use of the Ampere forces is formulated as a problem of non-linear optimization – it is required to find such parameters of a current system $\{r_i, I_i\}$, which could provide maximal stretching tension in the film structure and its zero magnetic moment. Matching the magnitude and the direction of currents in the structure can solve this problem.

As an example the distribution of radial component of the strain tensor in thin film structure with three concentric circular currents is found and compared with the strain magnitude in a case of only one conductor at the edge of plate. It is shown that the use of even small number of conductors allows substantial increasing the magnitude of strain stretching the plate. At the same time such scheme provides zero magnetic moment of the system due to use of oppositely directed currents of definite magnitude.

The obtained results can be applied for deployment of definite types of space structures such as thin film solar arrays or space sails made of flexible reflective polymer sheets.