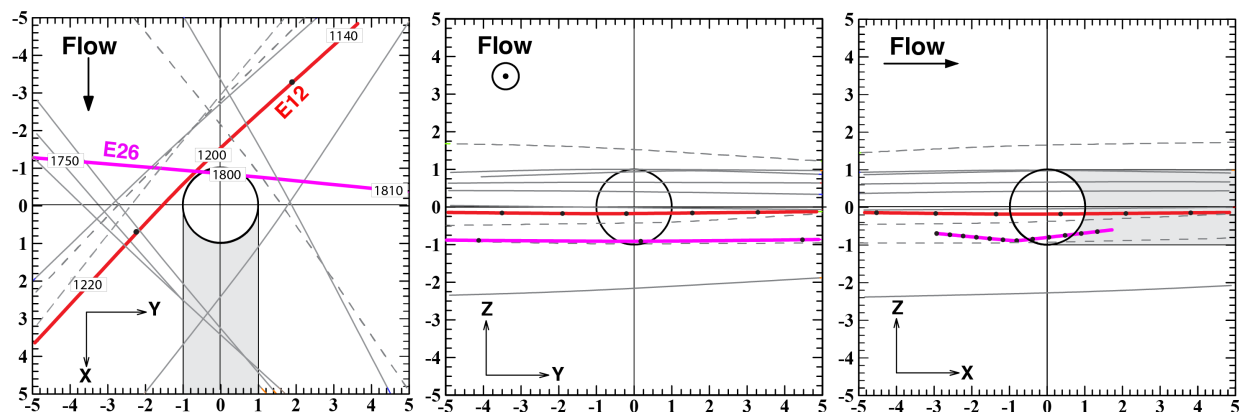


In the format provided by the authors and unedited.

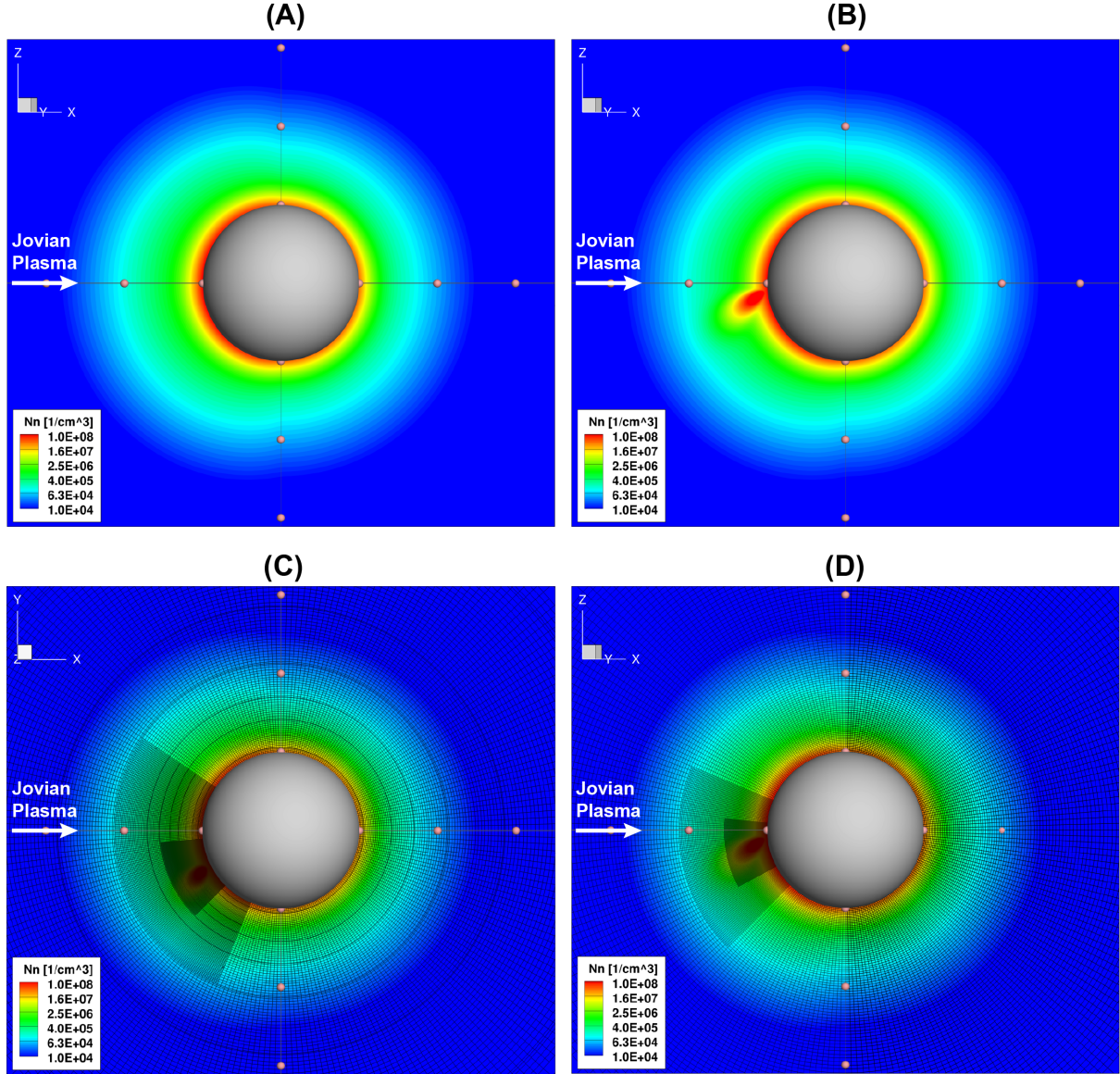
Evidence of a plume on Europa from Galileo magnetic and plasma wave signatures

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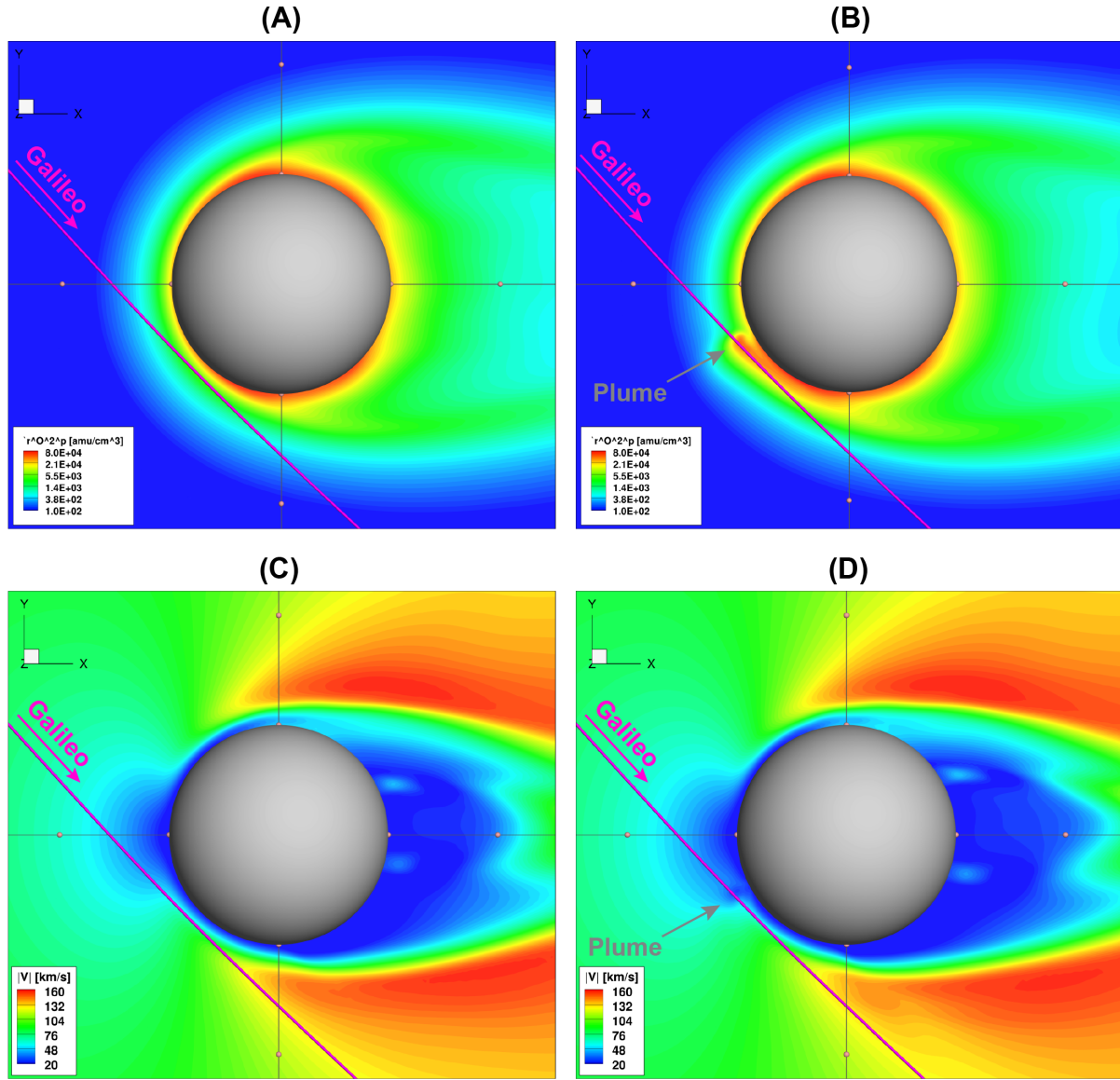
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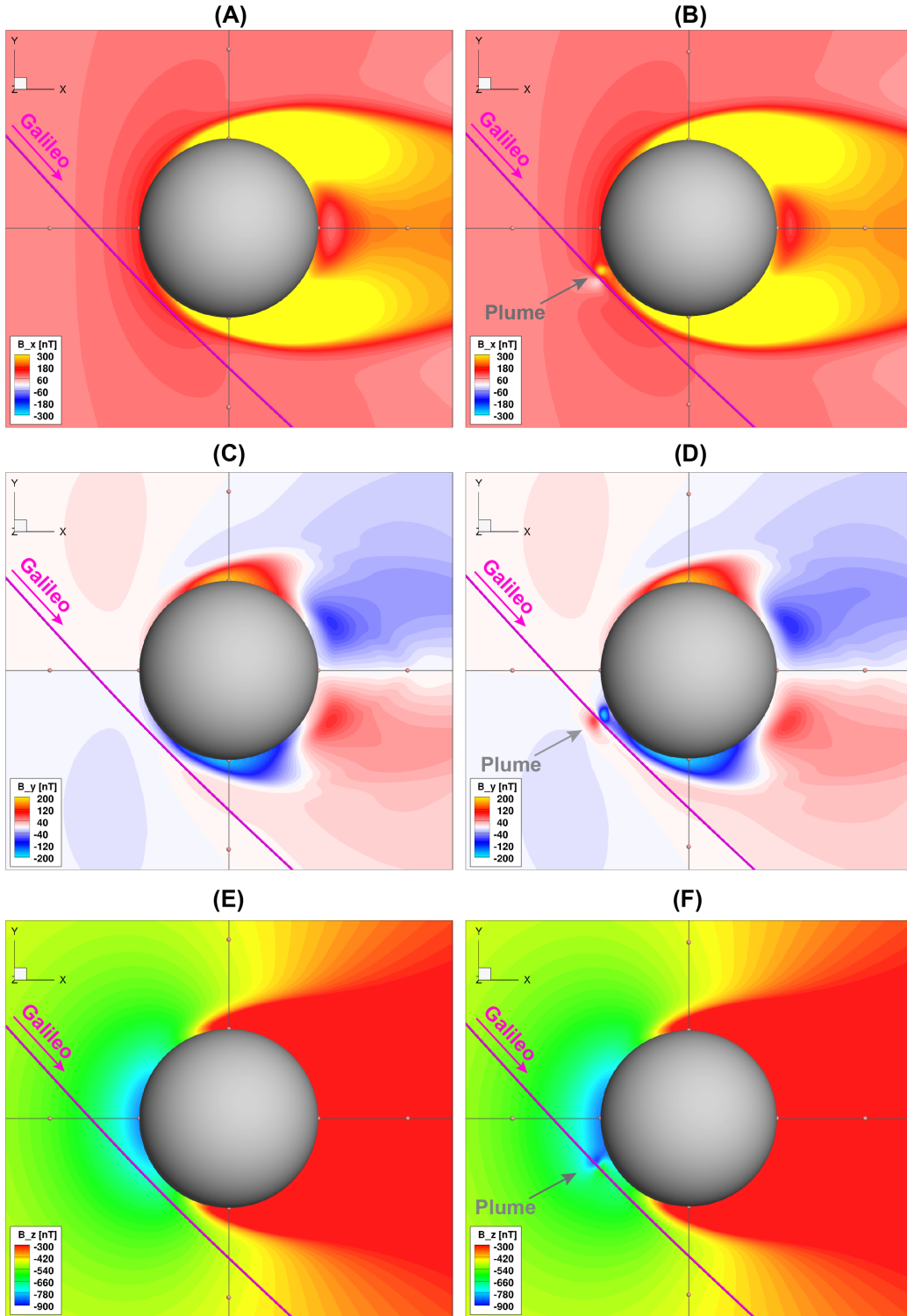
Supplementary Fig. 1. Galileo trajectories for all Europa encounters. The trajectories are shown in EphiO coordinates, with x parallel to Europa's orbital velocity, y directed toward Jupiter and z completing the right-handed system. The only two flybys that came within 400 km of the surface are E12 (red lines) and E26 (magenta lines) with C/A altitudes of 196 km for E12 and 348 km for E26. Recorded MAG data were lost on E6, E16, and E18 (dashed lines).



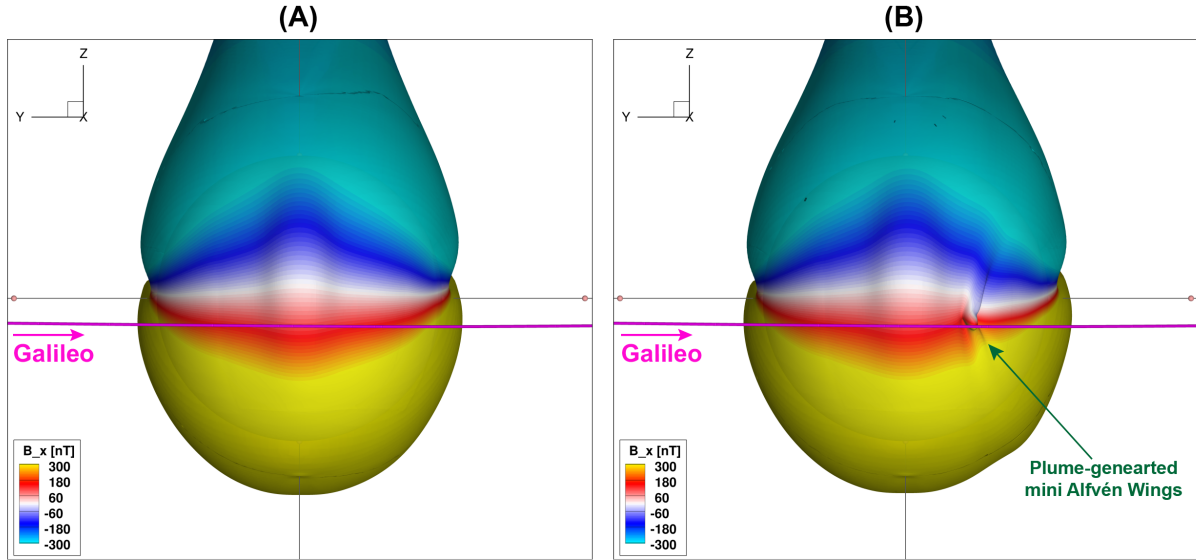
Supplementary Fig. 2. The density distribution of the exosphere and the plume used in our model. Color contours of the neutral density (in the units of cm⁻³) in the meridional cut that contains the central axis of the plume for (A) the background exosphere model and (B) the background exosphere plus the added plume. (C) Grid structure in the XY plane at Z=-0.2 R_E. (D) Grid structure in the same meridional cut as in (A) and (B). The background colors in (C) and (D) show the neutral density distribution with plume included. In each panel, the central grey sphere has a radius of 1 R_E and pink balls on the axes are separated by 1 R_E. Surrounding the entire plume is a wedge of high-resolution grid with smallest grid size of ~ 0.004 R_E or 6 km.



Supplementary Fig. 3. Comparison of the plasma density and flow speed between the simulations without and with a plume. Color contours of the mass density of O_2^+ (in the units of amu/cm^3) are plotted in (A) for the case without and in (B) for the case with the plume described in the text. (C) and (D) show color contours of the plasma flow speed (in units of km/s) correspondingly. All results apply to the XY plane at $Z = -0.2R_E$, approximately the plane containing the Galileo trajectory (magenta traces) near closest approach on the E12 pass.



Supplementary Fig. 4. Comparison of the magnetic perturbations between the simulations without and with a plume. Color contours of B_x , B_y and B_z (in units of nT) are shown for the case without the plume in (A, C, E) and for the case with the plume included in (B, D, F). As in Supplementary Fig. 2, all the results are extracted from and shown in the XY plane at $Z = -0.2R_E$ containing the Galileo trajectory.



Supplementary Fig. 5. Comparison of the global configuration of the interaction region around Europa between the simulations (A) without and (B) with a plume. In both panels, color contours of B_x (in nT) are shown on an iso-surface of plasma flow speed of 25 km/s, chosen to illustrate the global configuration of the interaction region around Europa. The view is from the ambient flow direction, and Jupiter is on the left (+Y side). The Galileo trajectory is along the magenta traces. In (B), a ridge-like structure forms in the region where the plume is placed in the simulation as a result of the plume-generated mini Alfvén wings.