Figure S1 reports the I-V behavior for silver-air-silver nanojunction with a gap of 1.2 nm and a cross-sectional area $\pi a^2 = \pi \times (5 \text{ nm} \times 5 \text{ nm})$. The work function of silver is 4.2 eV. This I-V behavior is calculated using the Simmon’s formula. When the nanoantenna is biased with a low dc voltage, which is less than the potential barrier height of nanojunction, the relationship between tunneling current and applied bias follows $I_{dc} \propto V_{dc} \exp \left( -\frac{2d \sqrt{2m\Phi}}{\hbar} \right)$. On the other hand, when the applied bias exceeds the barrier height, the current-voltage dependence is given
by \( I_{dc} \propto V_{dc}^2 \exp \left( -\frac{4d\sqrt{2m\Phi^3}}{3h\Phi V_{dc}} \right) \), which is in consistent with the Fowler-Nordheim formula for electron field emission. In order to characterize the voltage-current relationship, it is convenient to plot \( \ln \left( \frac{I_{dc}}{V_{dc}^2} \right) \) against \( \frac{1}{V_{dc}} \), as the well-known FN plot. For field emission, the FN plot yields a linear trend \( \ln \left( \frac{I}{V_{dc}^2} \right) \propto -\frac{4d\sqrt{2m\Phi^3}}{3h\Phi} \frac{1}{V_{dc}} \) with a negative slope that depends on the barrier height.

In the zero and low-bias direct tunneling regime, the FN plot exhibits a logarithmic growth as \( \ln \left( \frac{I}{V_{dc}^2} \right) \propto \ln \left( \frac{1}{V_{dc}} \right) - \frac{2d\sqrt{2m\Phi}}{\hbar} \). In the transition regime, the applied bias is near the barrier height, the mechanism experiences a transition from logarithmic growth to the linear decay. A transition from the direct tunneling to field emission will only be seen for the case of small barrier height and width, such as is found in the metal-molecule-metal nanojunctions.

**Intrinsic Dipole Impedance of Plamsonic Nanodipole Antenna**
Figure S2 Input impedance (blue and red solid lines are reactance and resistance, respectively) and dipole intrinsic impedance (blue and red dashed lines are reactance and resistance, respectively) for the nanodipole antenna.

Figure S2 reports the intrinsic impedance for the plasmonic nanodipole antenna with diameter $2a=10\ \textrm{nm}$, length $L=90\ \textrm{nm}$, and air gap $h=1.2\ \textrm{nm}$. Here the nanoantenna’s dipole arms are silver nanorods, with the relative permittivity following the Drude-type dispersion model:

$$\varepsilon_{Ag} = \varepsilon_\infty - \omega_p^2 / \left[\omega(\omega + i\gamma)\right],$$

with $\omega_p/2\pi = 2175\ \textrm{THz}$, $\gamma/2\pi = 4.35\ \textrm{THz}$, and $\varepsilon_\infty = 5$. 