



Analysis of Electromagnetic Properties from Time-Varying Moving Plasma with Lorentz-FDTD

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1. ABSTRACT

During flight of hypersonic vehicle, a layer of plasma sheath will be formed around the aircraft due to the high temperature. As the results of turbulence, the plasma sheath is time-varying. In addition, the hypersonic vehicle and plasma sheath keeps a high-speed relative motion with the radar on the ground. The plasma sheath will influence the original electromagnetic scattering properties of the aircraft, which will affect the normal observation of the aircraft from the radar. Therefore, it is significant to study the interaction between plasma sheaths and electromagnetic wave. In this paper, Lorentz-FDTD (Finite-Difference Time-Domain) method is used to analyze the electromagnetic properties of time-varying plasma sheaths in a 2-D case, and the result show that the time-varying and moving plasma will modulate the electromagnetic waves.

2. NUMERICAL RESULTS AND DISCUSSIONS

In this paper, we analyze the electromagnetic scattering properties of a time-varying plasma sphere with Lorentz-FDTD, and the radius of the plasma sphere is 0.425m.

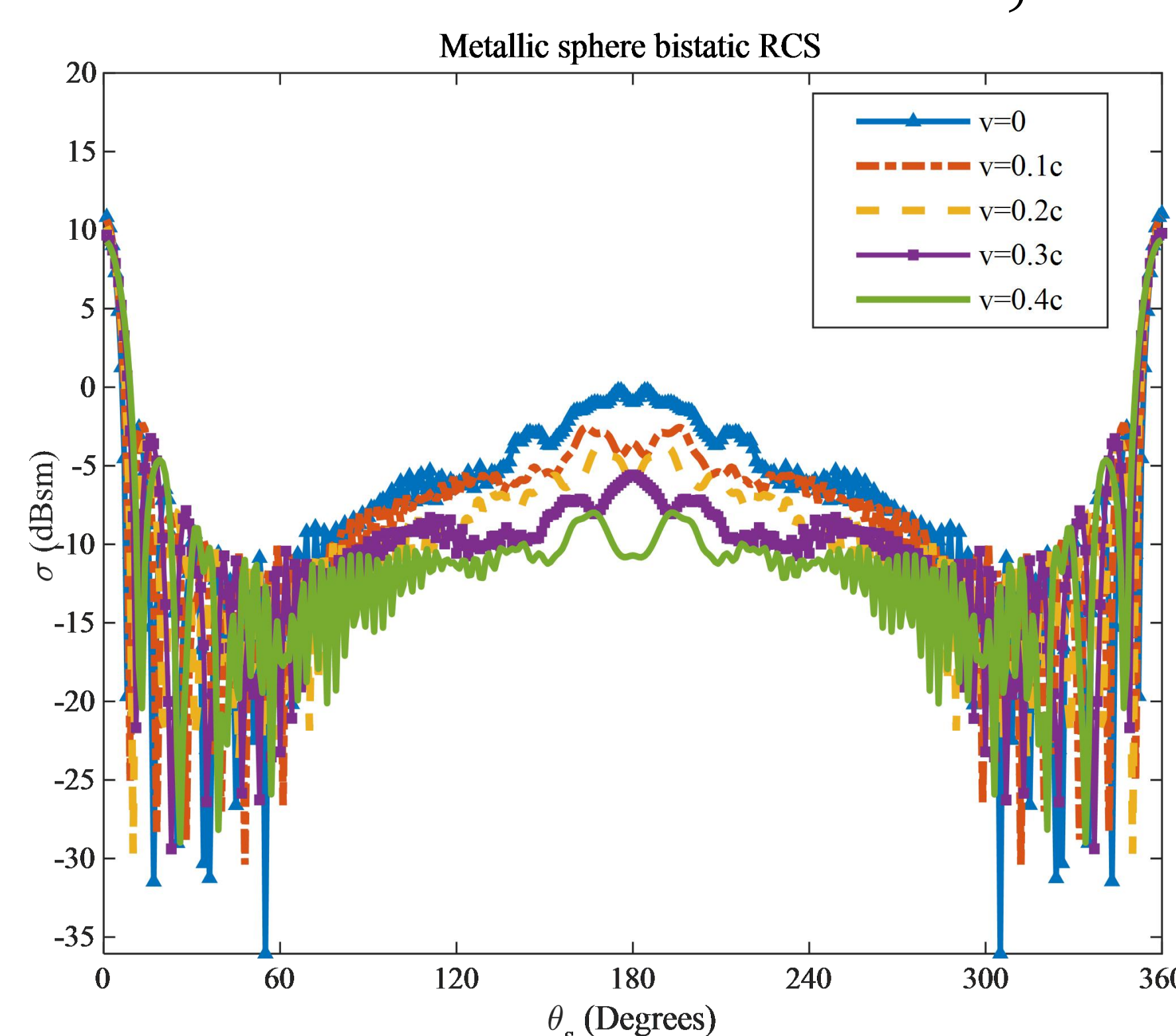


Fig. 1. Metallic sphere bistatic RCS

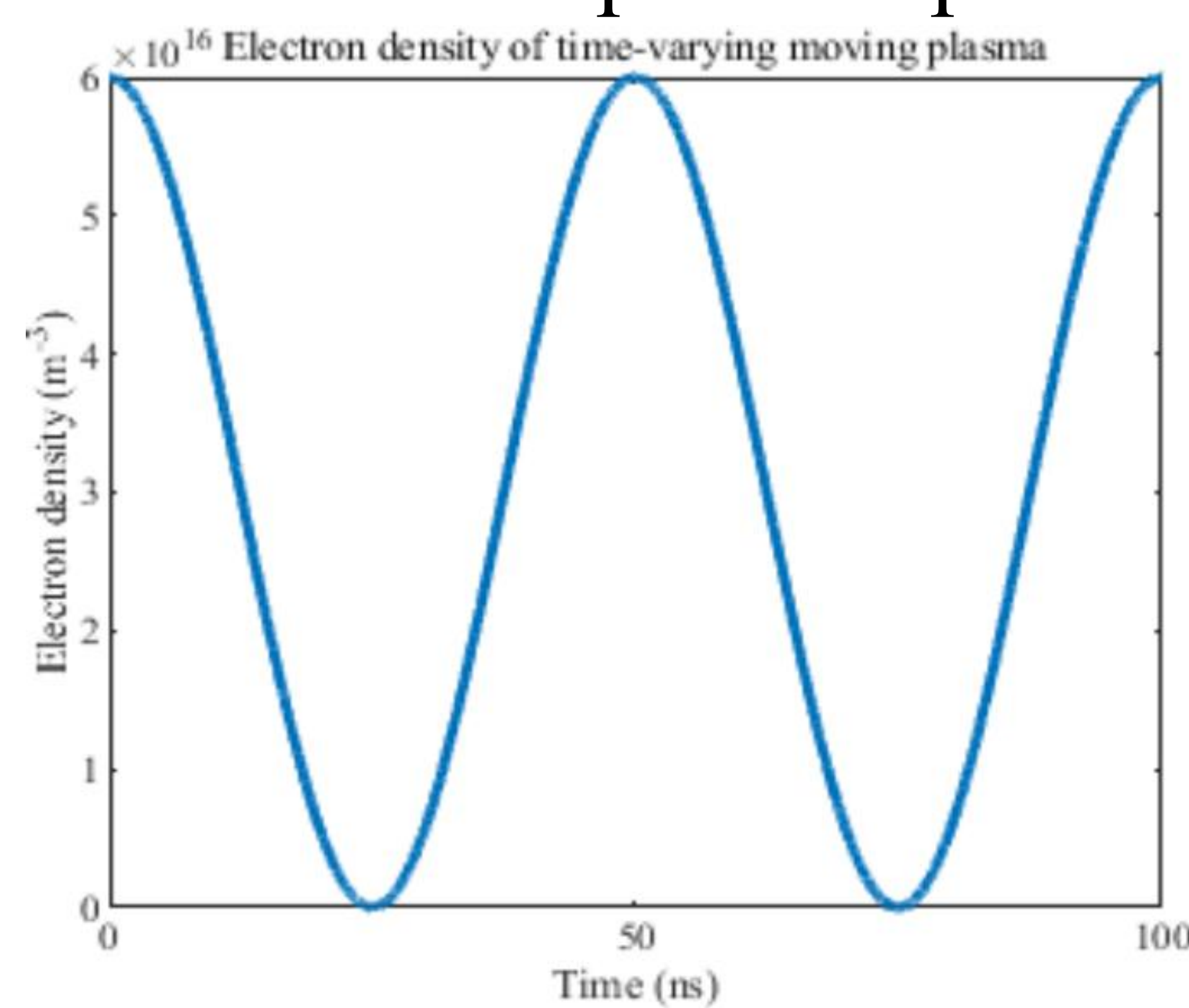


Fig. 2. Variation of electron density of time-varying moving plasma vs time

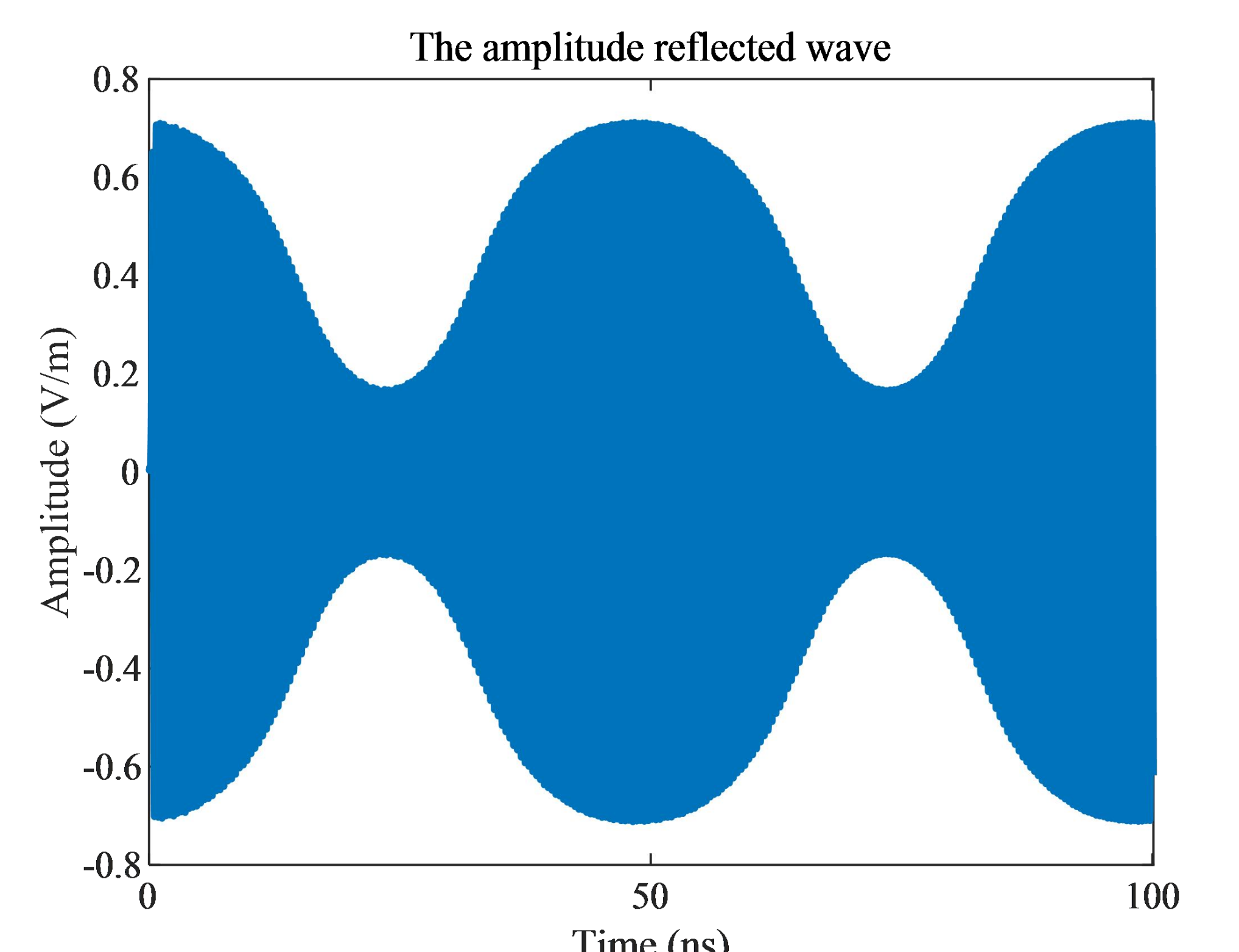


Fig. 3. Envelope diagram waveforms of electromagnetic waves reflected from periodic time-varying moving plasma

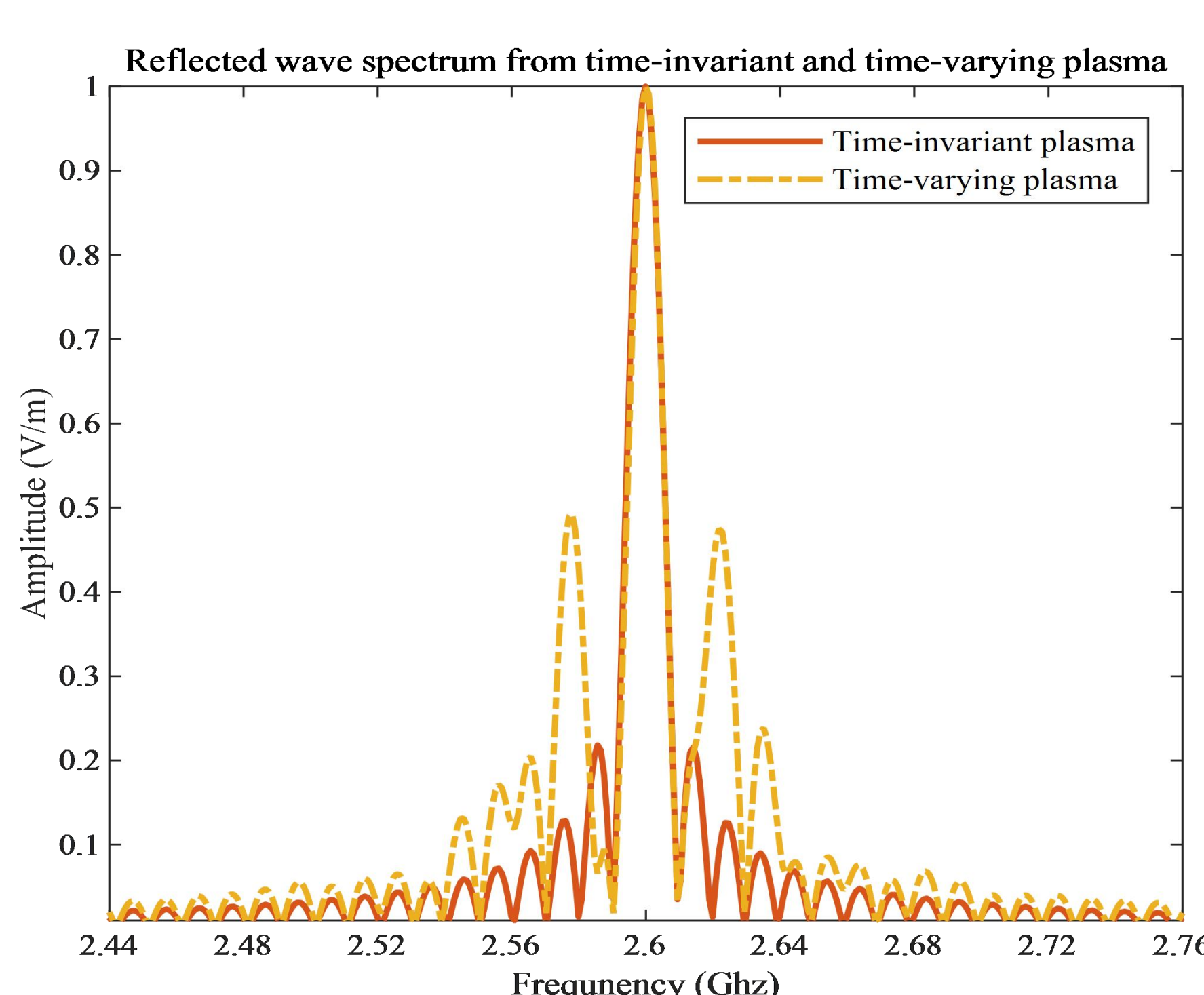


Fig. 4. Reflected wave spectrum from time-invariant and time-varying plasma

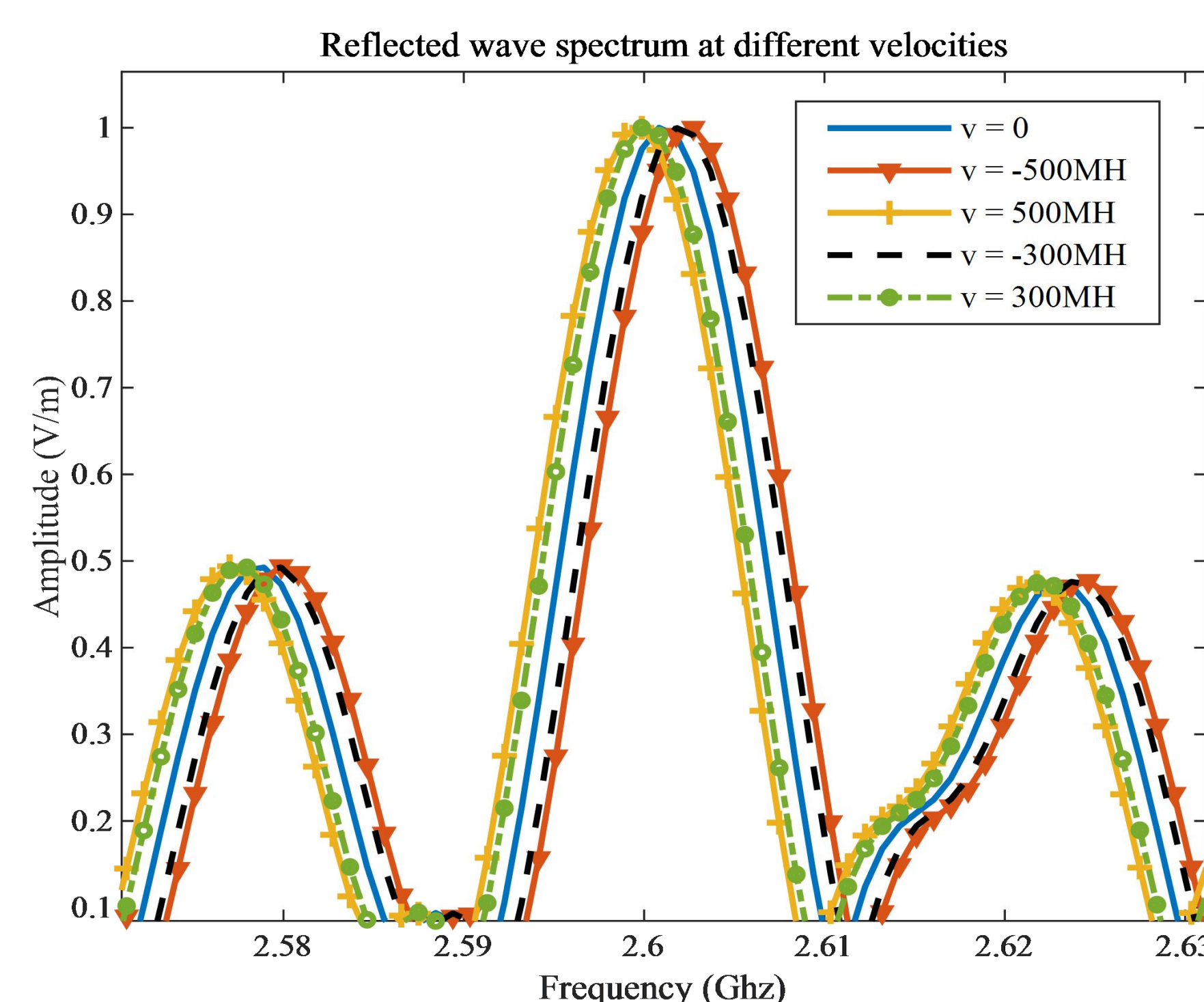


Fig. 5. The electromagnetic spectrum reflected by the time-varying plasma at different velocities

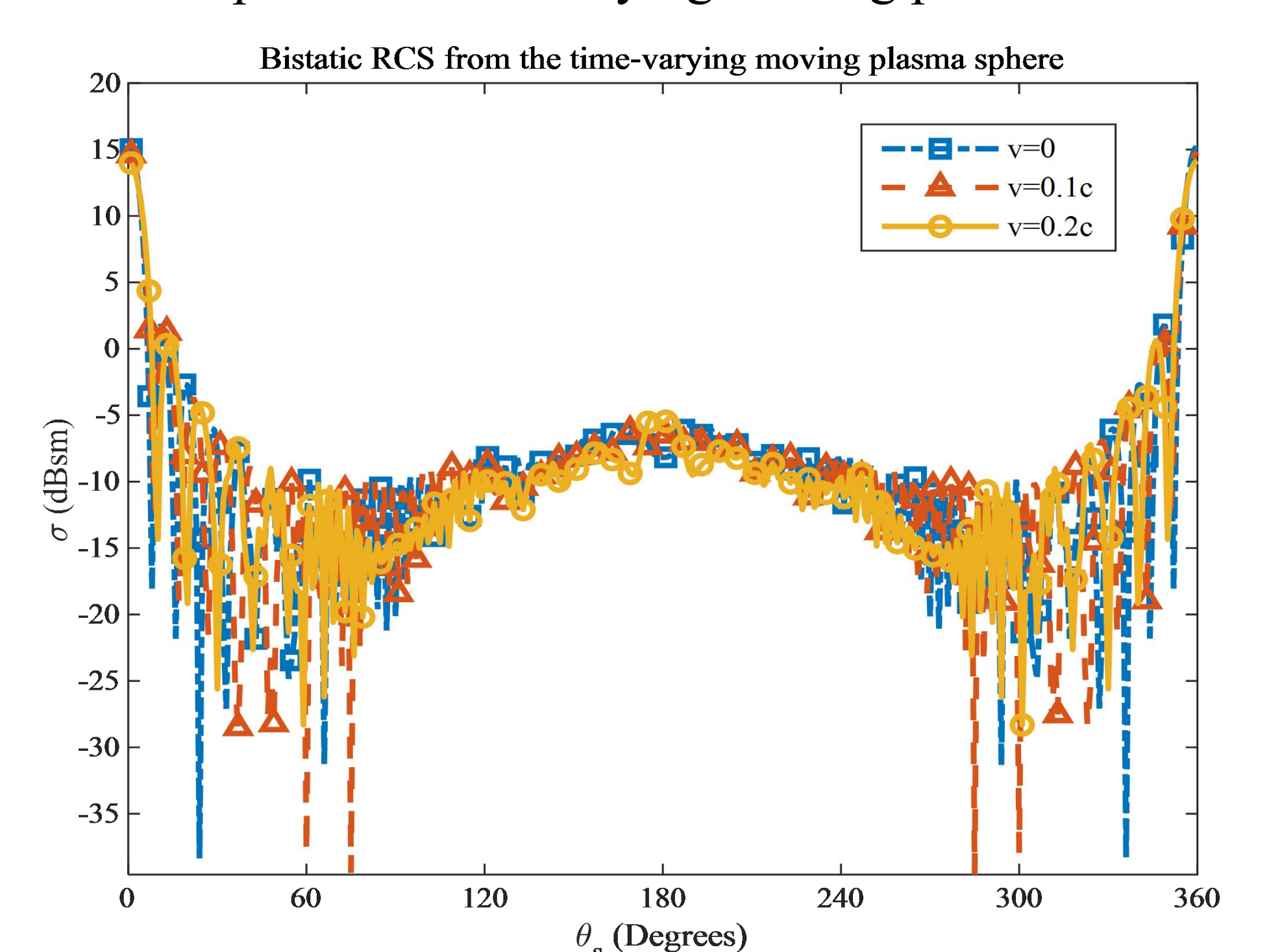


Fig. 6. Bistatic RCS from the time-varying moving plasma sphere

3. CONCLUSION

In this paper, numerical results of time-varying moving plasma object are calculated using the Lorentz-FDTD method. On the basis, the effect of time-varying moving plasma on the propagation properties of electromagnetic wave is analyzed. Simulation calculations have shown that the reflected wave spectrum is modulated by the periodic time-varying plasma. Besides, the Doppler effect of electromagnetic waves caused by moving plasma is observed. Although only a 2-D time-varying moving plasma is considered in this paper, the propose method also can be applied to 3-D cases. The effect of time-varying plasma on the scattering properties of electromagnetic waves is studied, and the effect of other parameters of plasma will be studied in the future.