Two Streaming Instabilities in Semiconductor Quantum Plasma

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The analysis addresses multi-time-scale instabilities and includes both nearly degenerate and nearly non-degenerate cases. The real frequency and growth rate of the two-stream instabilities are analyzed numerically using standard parametric values for InP and GaN semiconductors materials. In both regimes, the species density and instability phase velocity are found to be inversely related. The system's instability grows with increasing electron streaming velocity and decreases with increasing hole streaming velocity. In nearly degenerate plasmas, growth rates are lower when species temperatures are equal compared to differing temperatures ($T_e > T_h$) and higher compared to $T_e < T_h$.

Temperature change little affects the growth rate in almost non-degenerate scenarios, highlighting the dominance of other quantum processes. In both the nearly degenerate and nearly nondegenerate regimes, the exchange-correlation potential enhances plasma instability, while tunneling recoil and degeneracy pressure significantly reduce instability at larger wave numbers. This thorough study offers insightful information about the quantum behavior of semiconductor plasmas, which is relevant to semiconductor physics and electronic device applications.

References

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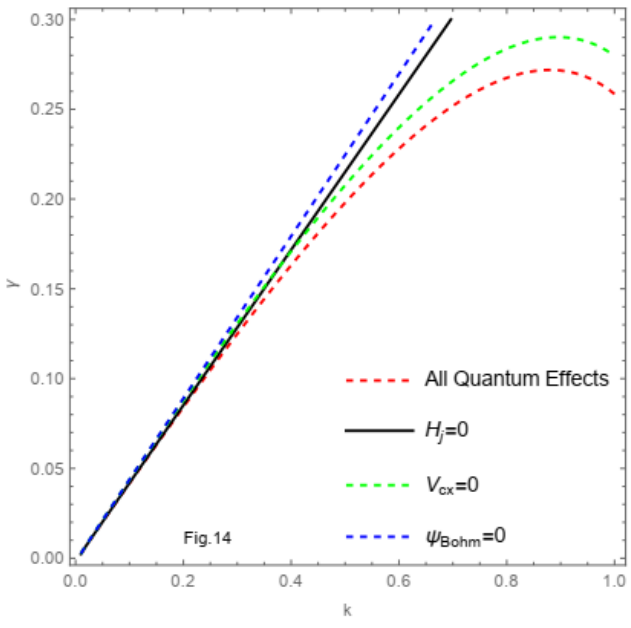

Figure 1. Normalized growth rate γ as a function of wave number k for InP semiconductor material. The red dashed curve includes all quantum effects, the black bold curve excludes the He,h term, the green dashed curve omits the exchange-correlation effect, and the blue dashed curve excludes the Bohm potential term.