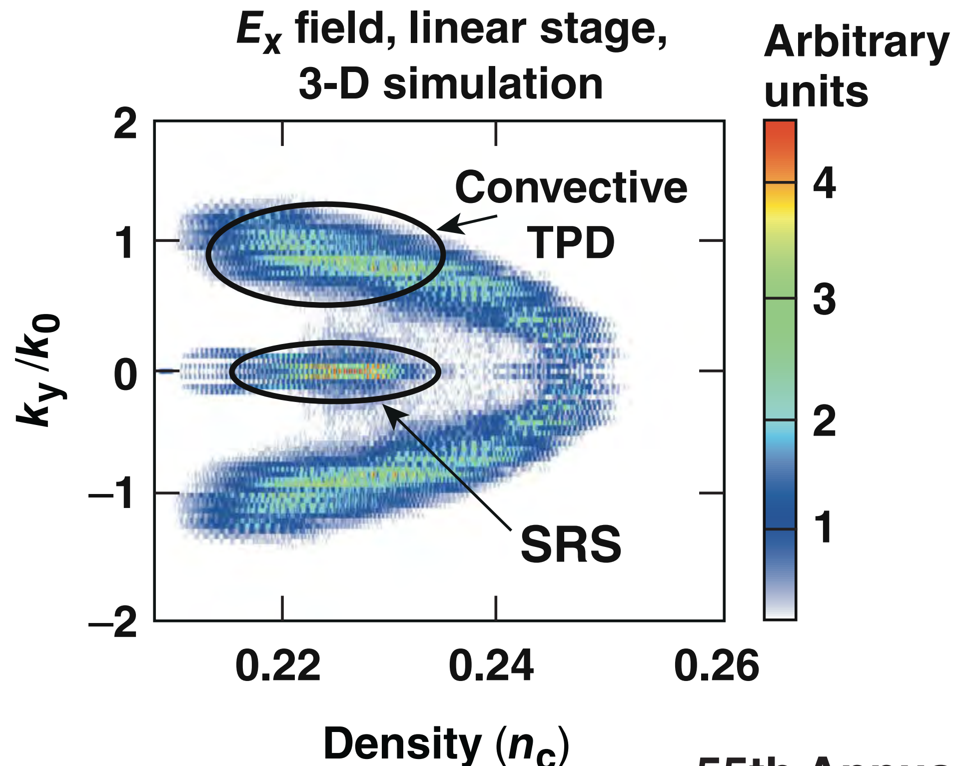
Three-Dimensional Modeling of the Two-Plasmon–Decay Instability and Stimulated Raman Scattering Near the Quarter-Critical Density in Plasmas



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Summary

In 3-D particle-in-cell (PIC) simulations, the coexistence of two-plasmon decay (TPD) and stimulated Raman scattering (SRS) is observed near the quarter-critical density

- The results of three PIC simulations (3-D, 2-D in-plane, and 2-D out-of-plane) have been compared
- TPD and SRS spectral features in 3-D simulations are in agreement with respective 2-D simulation results
- Field energy levels in PIC simulations indicate that SRS is important in the saturation stage

Collaborators

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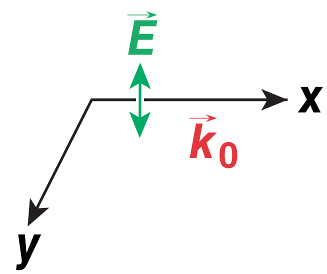
PIC simulations have been performed for parameters relevant to direct-drive inertial confinement fusion experiments

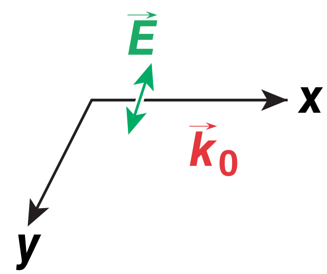
- Physical parameters
  - scale length $L_n = 100\ \mu m$
  - intensity $I = 2.7 \times 10^{15}$ W/cm^2
  - CH plasma, temperature $T_e = 2$ keV, $T_i = 1$ keV
  - laser propagates along the x axis
  - linear density profile from 0.21 to 0.26 n_c
- Numerical parameters
  - simulation box size: $400 \times 150 \times 32\ c/\omega_0$ ($21 \times 8 \times 1.7\ \mu m$) for 3-D simulation, $400 \times 300\ c/\omega_0$ ($21 \times 16\ \mu m$) for the two 2-D simulations

2-D simulations are in the x–y plane

2-D out-of-plane

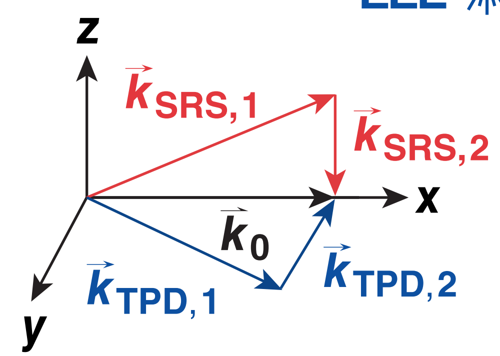


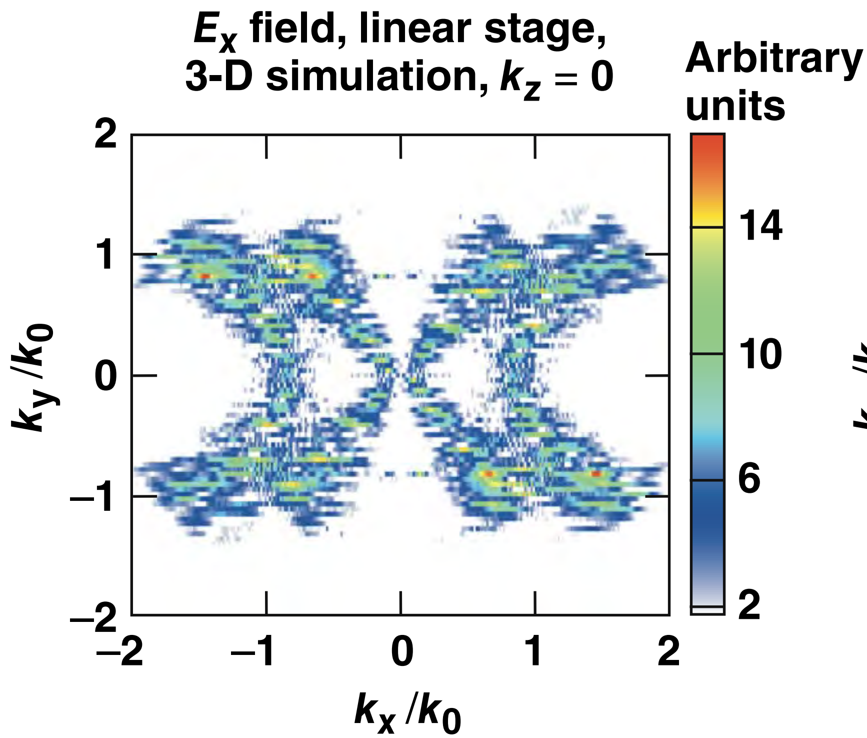
2-D in-plane

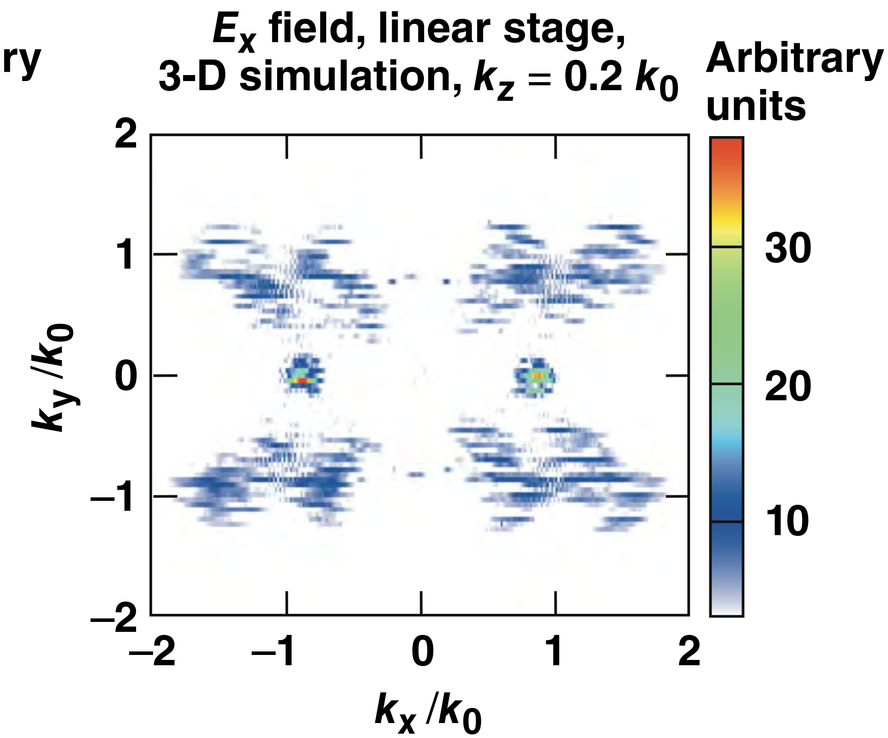


Both TPD and SRS features are observed in the field spectra in the linear stage of the 3-D PIC simulation

- TPD is localized in *x*–*y* plane
- SRS side scattering is observed at $k_z \neq 0$
- SRS scattered light has a small wave vector compared to k_0







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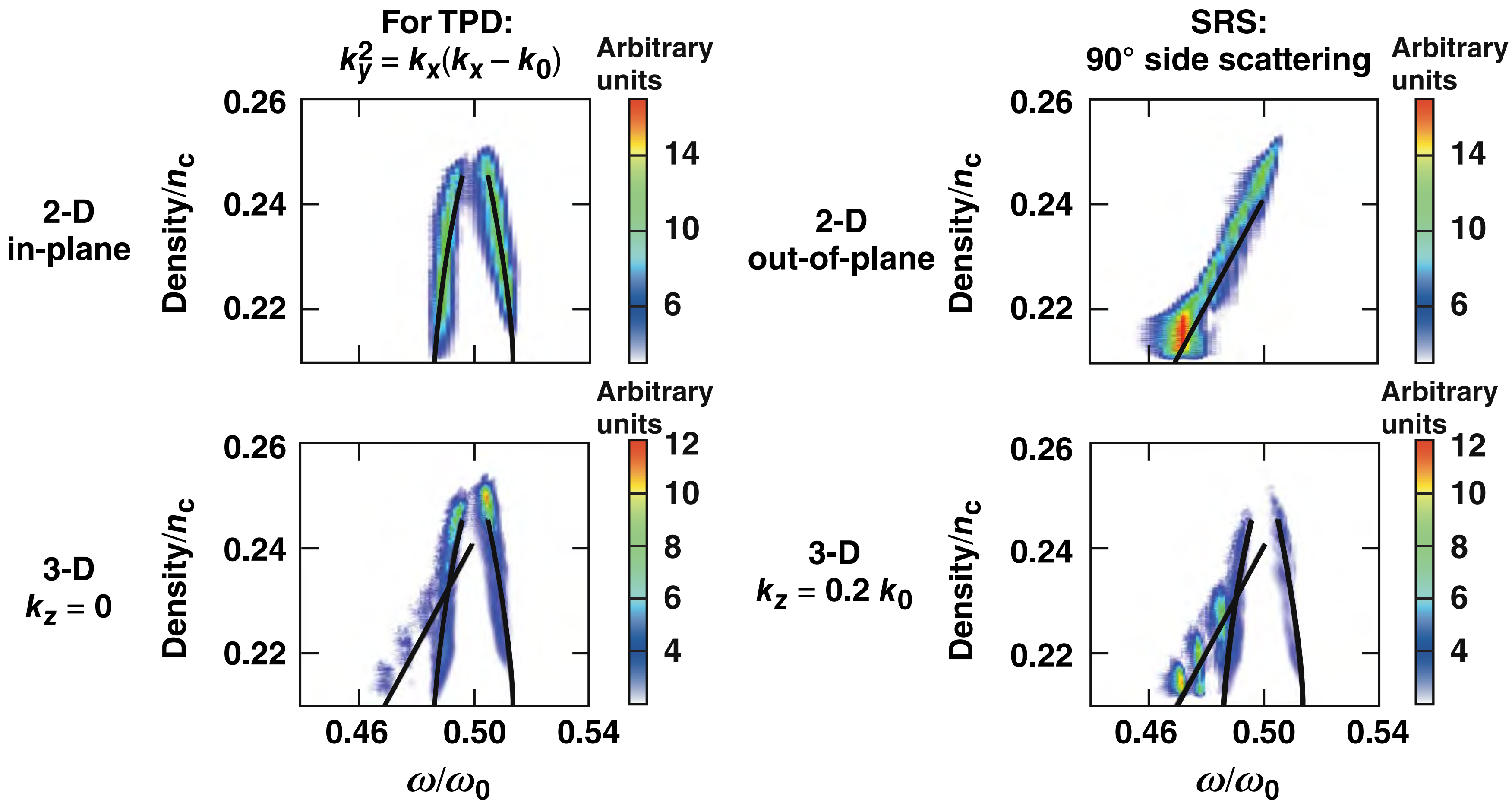
TPD and SRS features are identified in the frequency spectra of plasma daughter waves in the linear stage of 2-D and 3-D simulations

- **Solid black lines:** $\omega_1 + \omega_2 = \omega_0$, $\vec{k_1} + \vec{k_2} = \vec{k_0}$



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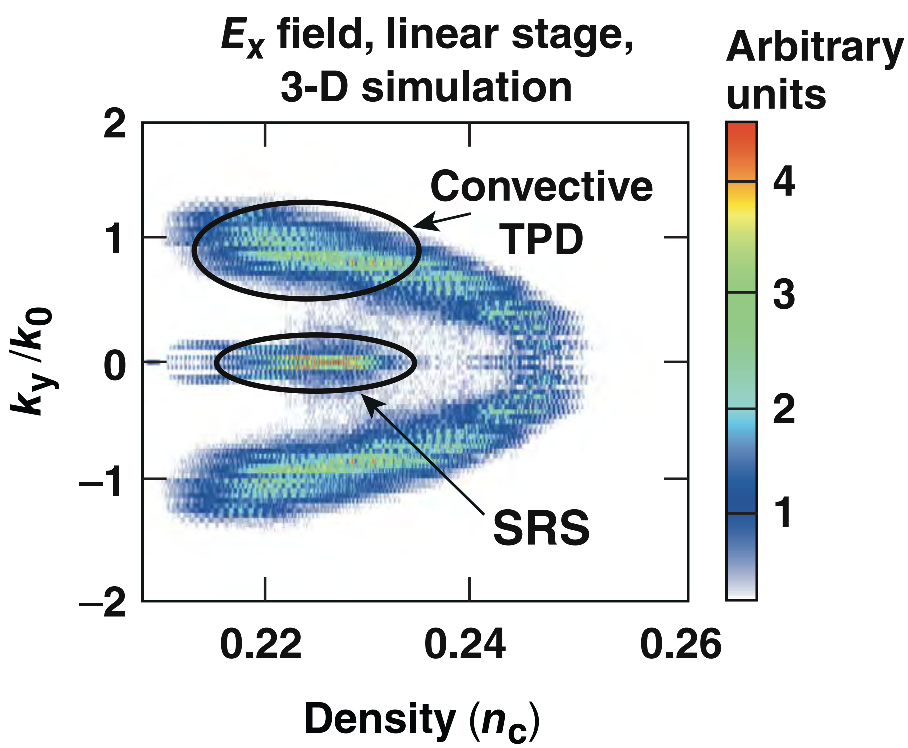
TPD and SRS develop independently in the linear instability stage

- Spectra are Fourier-transformed in two transverse directions and averaged over k_z
- The growth rates of TPD and SRS are comparable



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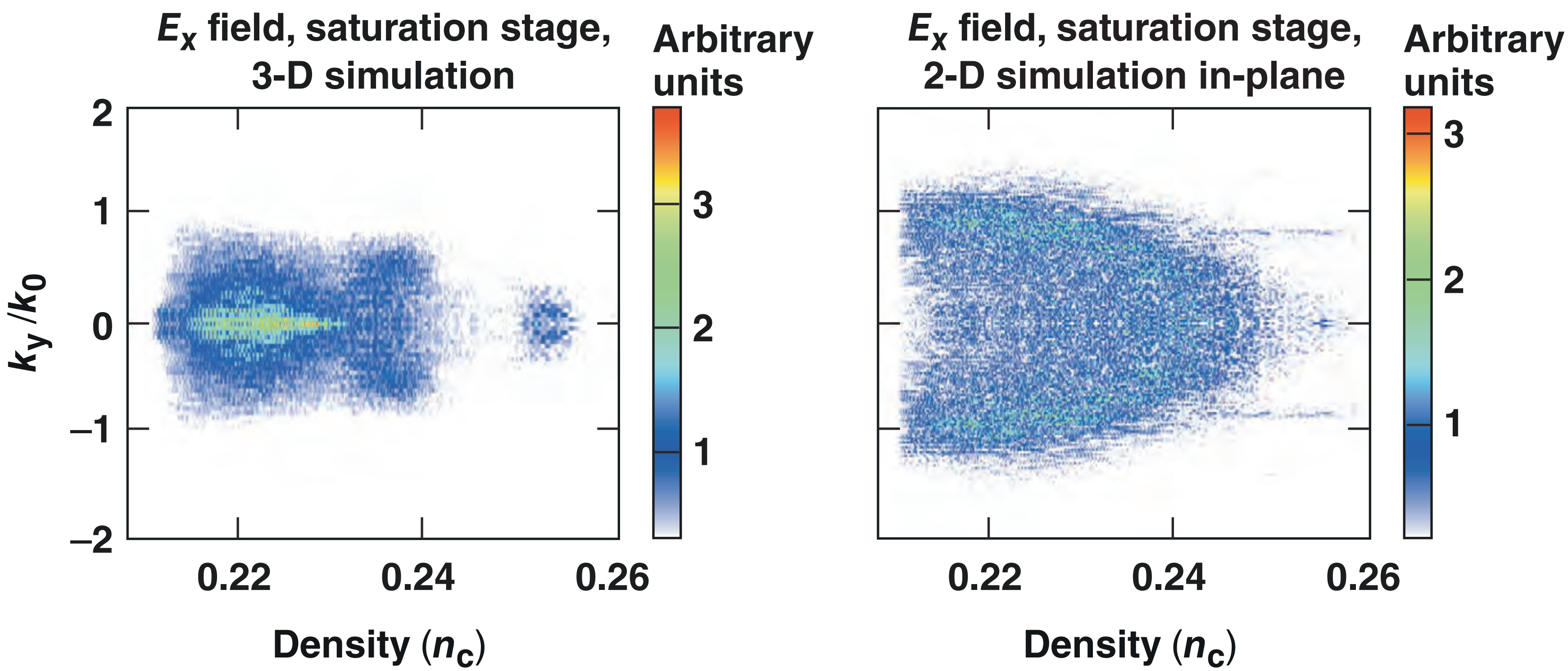
SRS is important in the instability saturation stage

- The field energy in the simulated region reaches a quasi-steady state at ~1 ps
- SRS accounts for more than 50% of the total field energy associated with the instability



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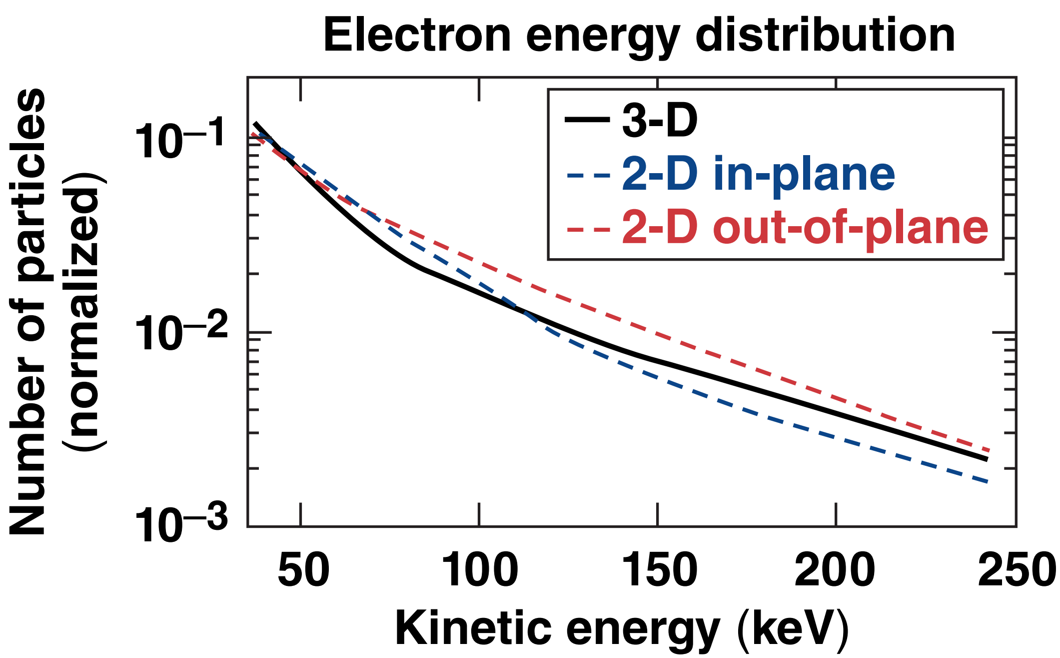
The temperature and flux of fast electrons in 3-D and 2-D PIC simulations are close

- The distribution is fitted with the expression *A* exp(–*KE*/*T*), where *KE* is the kinetic energy and *T* is the temperature of hot electrons



	3-D	2-D in-plane	2-D out-of-plane
Temperature (keV)	28.1	22.9	29.2
Energy flux (carried by electrons above 50 keV)	21.1%	19.9%	21.3%

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Summary/Conclusions

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