INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
34100 TRIESTE (ITALY) - P.O.B. 586 - MIRAMARE - STRADA COSTIERA 11 - TELEPHONE: 2240-1
CABLE: CENTRATOM - TELEX 460392-1

H4.SMR/210 - 8

SPRING COLLEGE ON PLASMA PHYSICS

(25 May - 19 June 1987)

EXPERIMENTS ON PARAMETRIC INSTABILITIES AT UCLA

C. JOSHI

University of California
U.S.A.

EXPERIMENTS ON PARAMETRIC INSTABILITIES AT UCLA

C. JOSHI

In collaboration with

C. Clayton, F. Chen, C. Darrow,

D. Umstadter and R. Williams.

1) Stimulated Brillouin Backscatter

: Evidence for a convective instability

: Evidence for harmonics

2) Filamentation of laser light

3) Stimulated Raman Backscatter

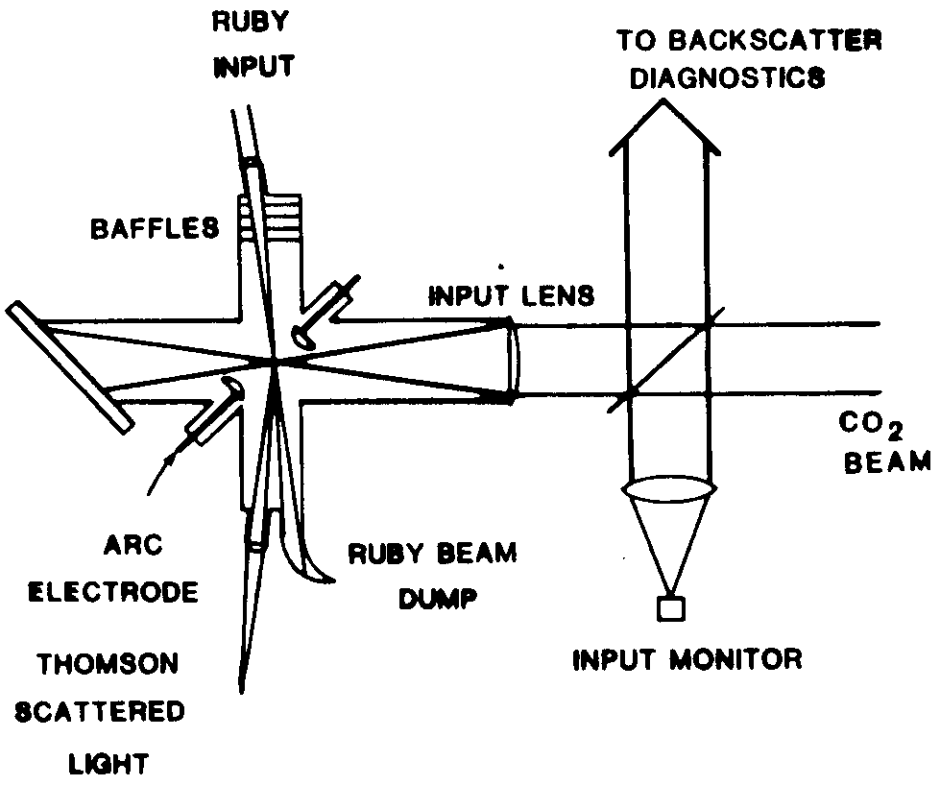
: Plasma Wave Nonlinearities

4) Mode coupling of plasma waves due to an ion ripple

Stimulated Brillouin Scattering

$\omega_0 = \omega_s + \omega_{ac}$ $\qquad \omega_{ac} = k_{ac} c_s$.

$\underline{k}_0 - \underline{k}_s = \underline{k}_{ac}$



CO_2 laser $\quad I \sim 10^{11}$ w/cm^2 $\quad$ 50 ns (FWHM)

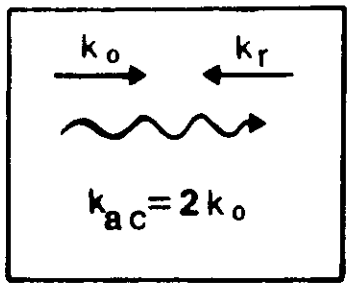
$n_e \sim 10^{17}$ cm^{-3} (N_2 plasma)

Schinzel - Wed Thurs

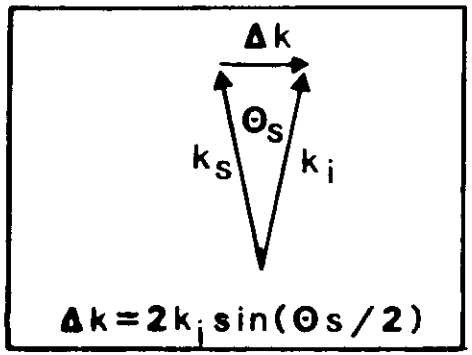
Gusciora - Thurs Wed Friday.

Kinetic Phenomena for High Energy Particles of Laser Produced Plasmas.

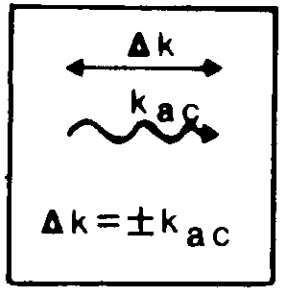
THOMSON SCATTERING THEORY



SBS ION WAVE



SCATTERING GEOMETRY

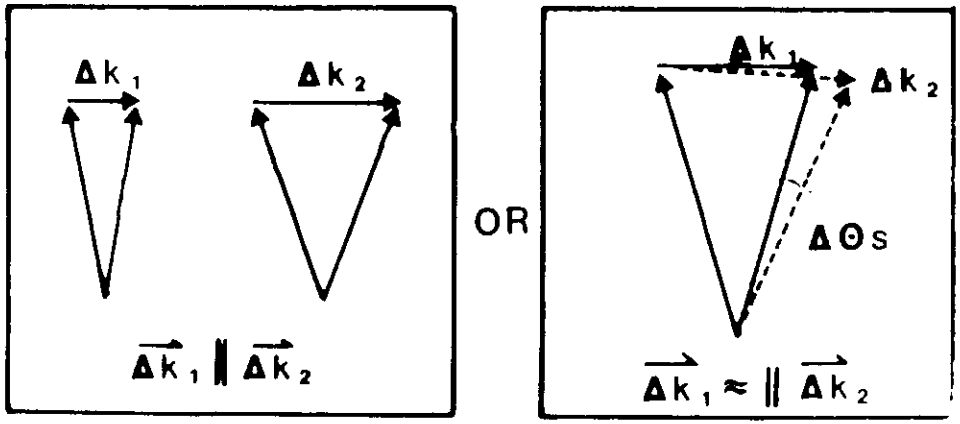


k-MATCHING

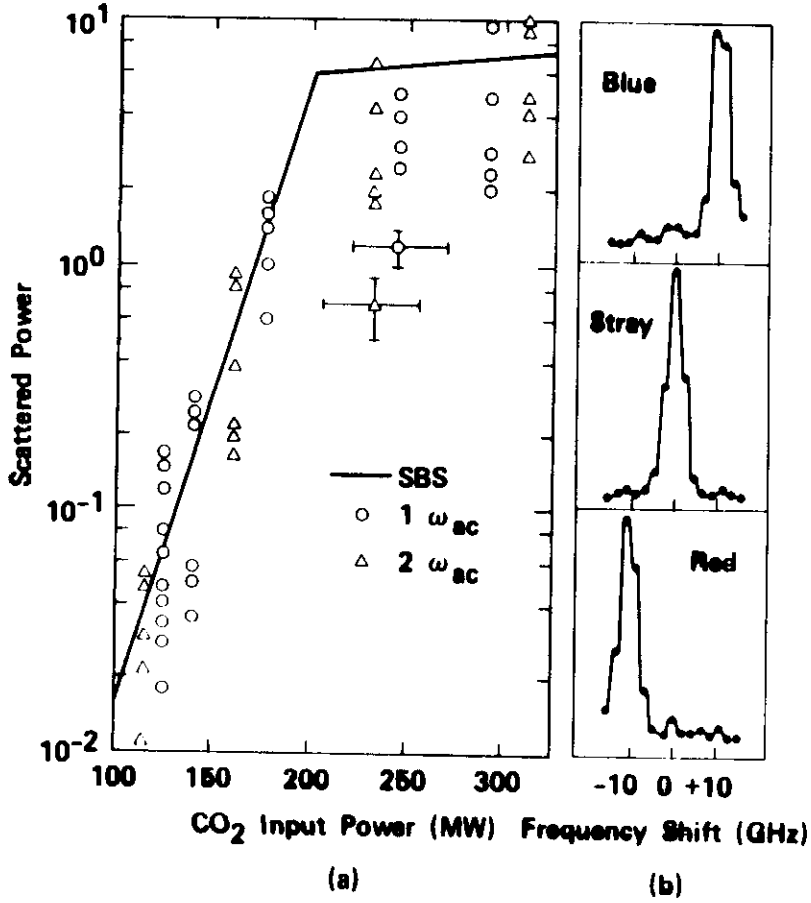
$\Rightarrow$

$\Theta_s = 7.5^\circ$

$$P_s \approx P_o \left(\frac{\pi}{2} \frac{n_o}{n_{ci}} \frac{\pi}{n_o} \frac{d}{\lambda_i} \right)^2$$

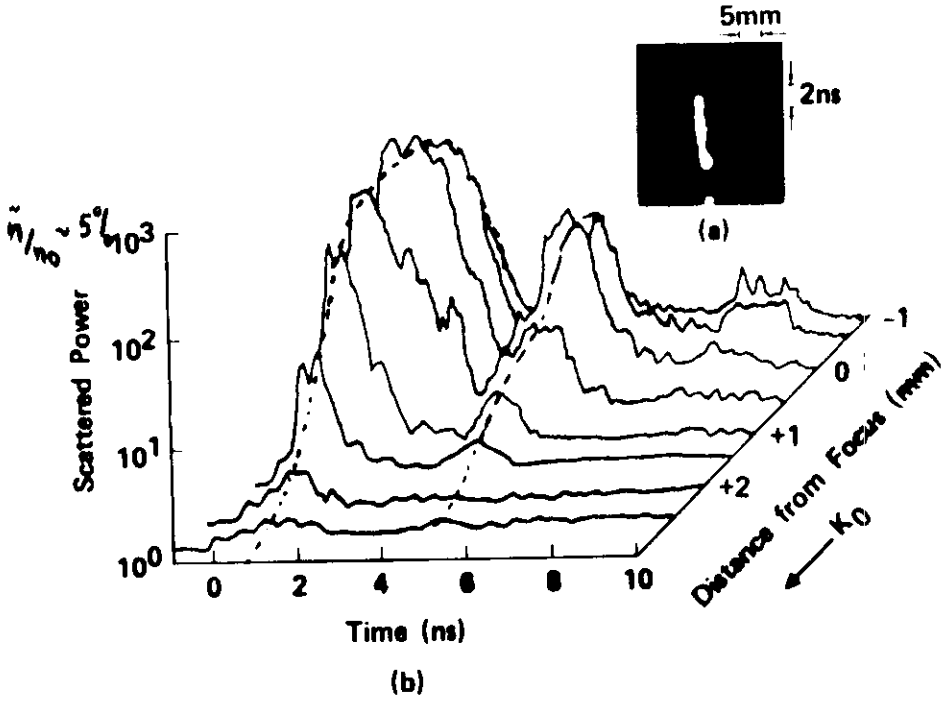


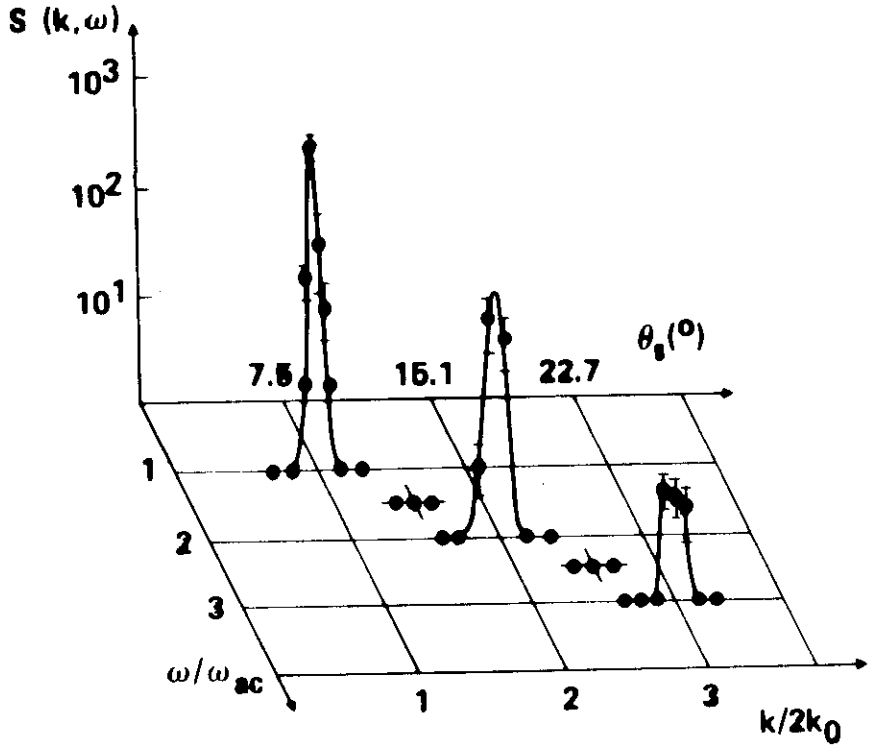
k-SPECTRUM



COMPLETE ION WAVE SPECTRUM SHOWI

SBS and HARMONICS.

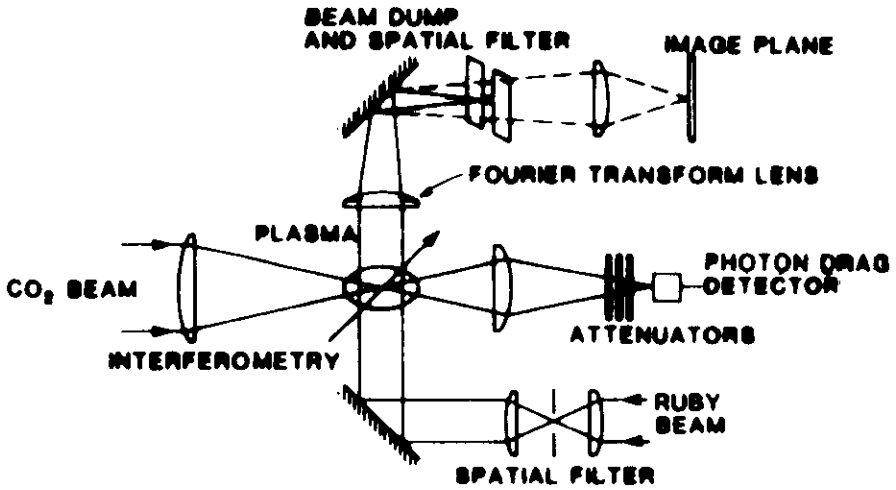




Ref. C. Clayton, C. Joshi and F. Chen

Phys. Rev. Lett. 51, 1656 (1983)

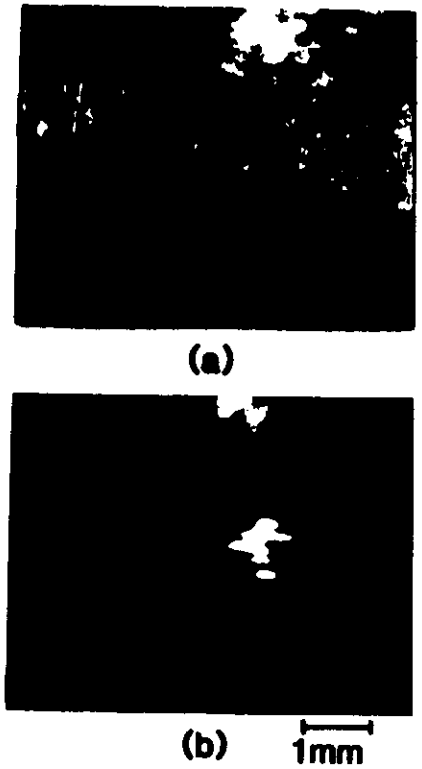
DARK FIELD TECHNIGUE FOR OBSERVING DENSITY SIRIATIONS DUE TO FILAMENTATION.



$n_e \sim 10^{18}$ cm^{-3}

$I \sim 10^{11} - 5 \times 10^{11}$ W/cm^2

$(\delta n_0/n_{HV})^2 \sim 0.1\%$



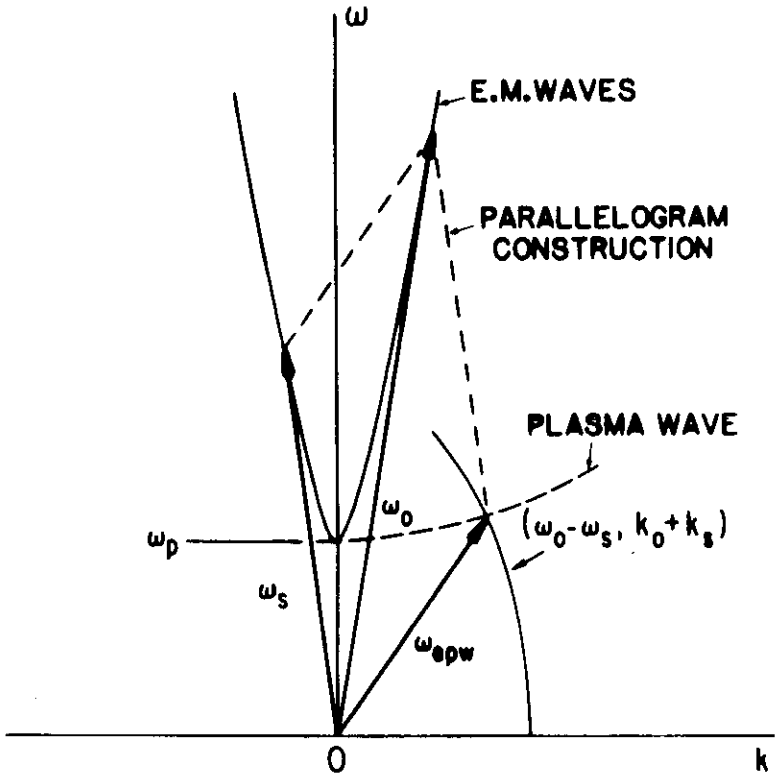
Reference

Filaments.

$k_1 \sim 256$ cm^{-1}.

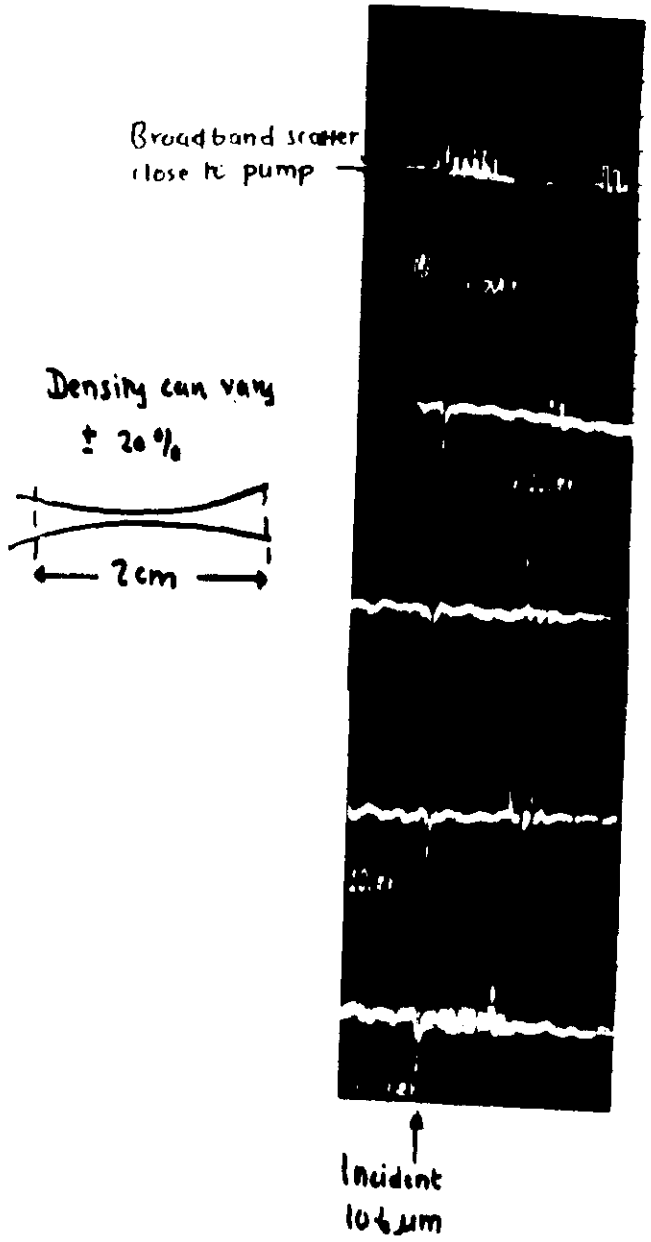
Ref: C. Joshi et. al. J. Appl. Phys. 53, 215 (1982)

Dispersion Relation for the SRS Instability.



Raman Backscatter Spectra

Infrared Image Disector and Ge:Cu Cold Detector.



Density deduced from Raman backscatter.

$8.9 - 10.1 \times 10^{16}$ (cm^{-3})

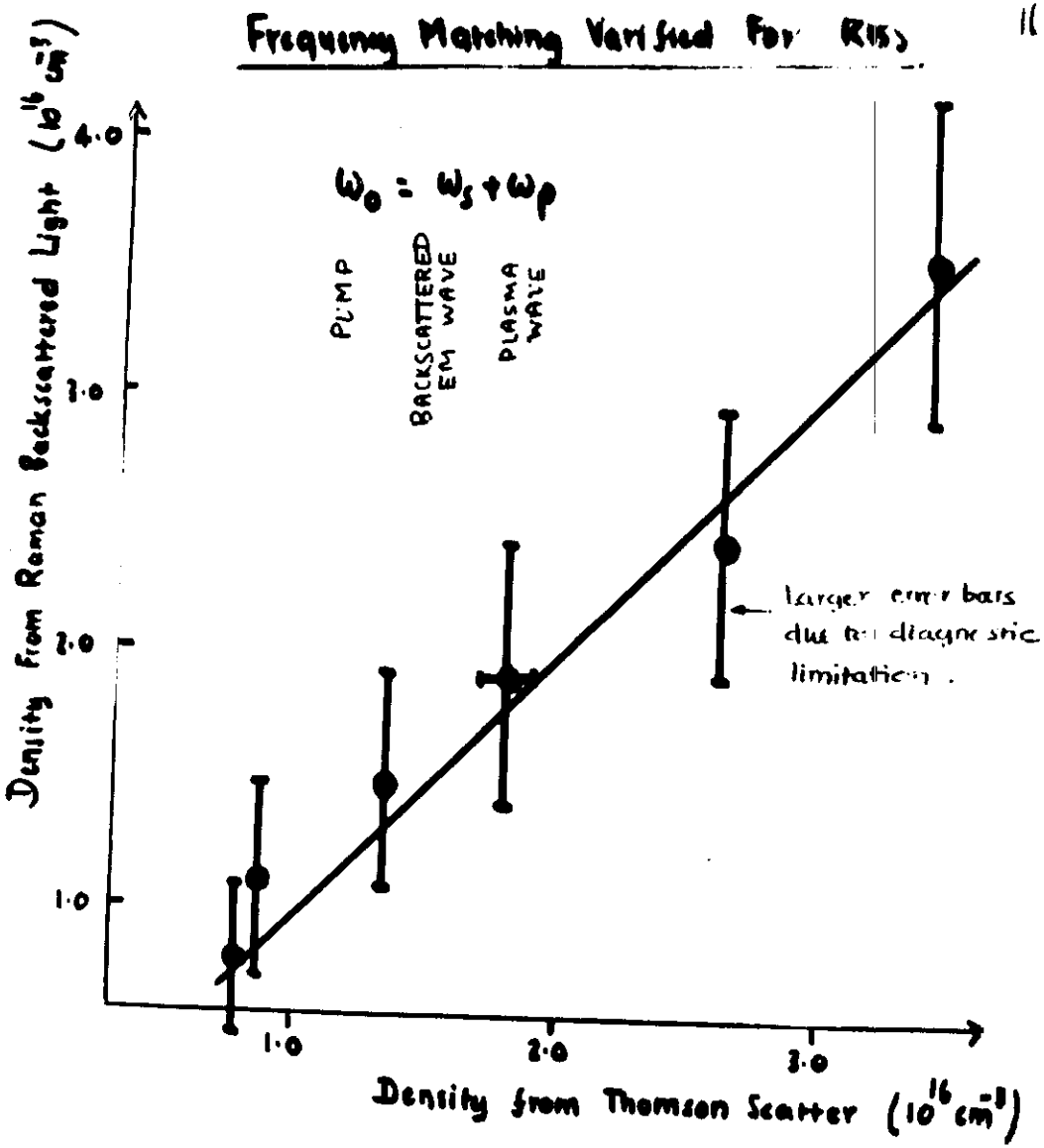
$4.8 - 5.72 \times 10^{16}$ (cm^{-3})

$3.9 - 4.8 - 5.72 \times 10^{16}$ (cm^{-3})

$3.2 - 3.9 - 4.8 \times 10^{16}$ (cm^{-3})

2.45×10^{16} (cm^{-3})

Frequency Matching Verified For RBS



MODE COUPLING AT $2K_0$

SINGLE FREQUENCY EXCITATION

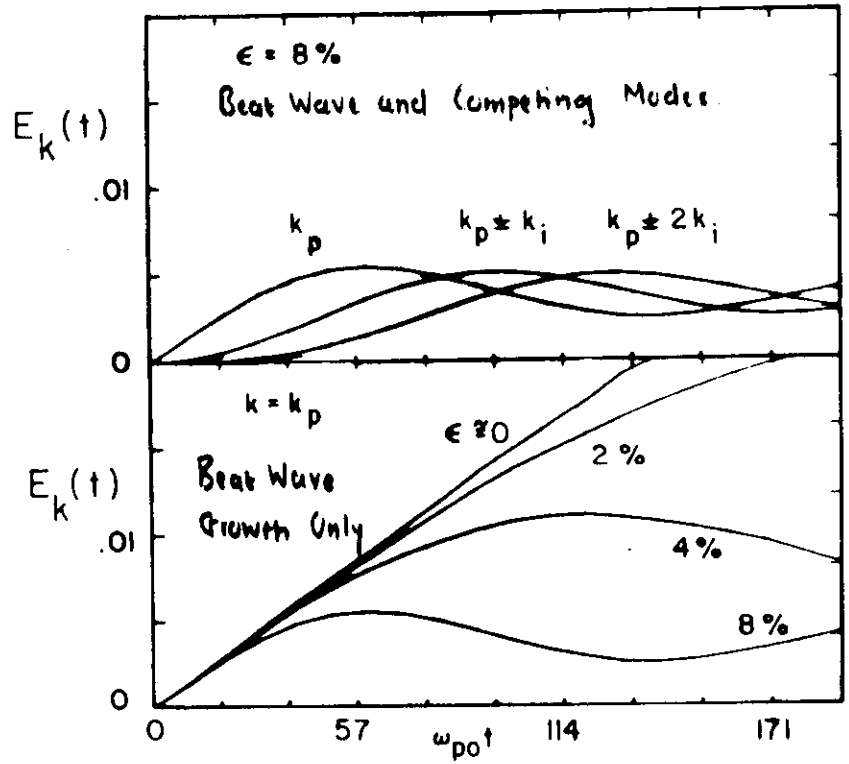
Signal red shifted by ω_p implies a backward going plasma wave with $\Delta k \simeq 2k_0$

Could either be due to mode coupling or the so-called parametric decay instability.

$\omega_p, 2k_0 \quad \omega_p - \varepsilon, -2k_0$

$\varepsilon, 4k_0$ may be seeded by 2nd Harmonic of

Mode Coupling Occurs on Timescale of a few Picoseconds



Mode Coupling Dominates Relativistic Detuning Whenever

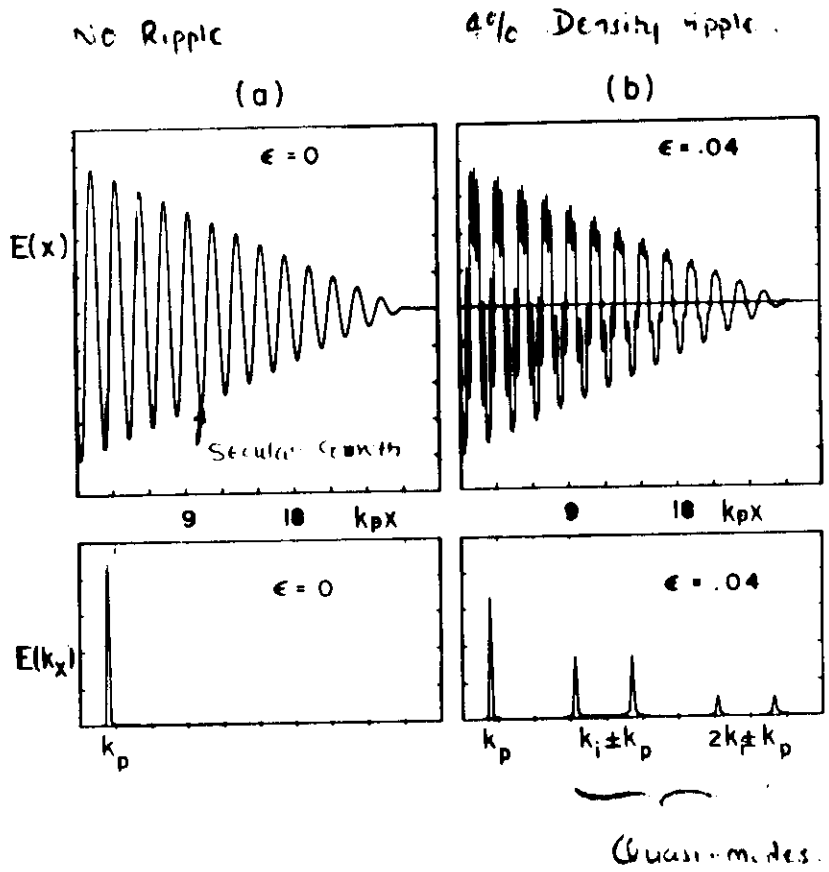
$$a_1 a_2 < [1.6\, t / f(p)]^{3/2}$$

$$f(p) = p + (1+p^2)(2+p^2)^{-1/2}, \quad p = (3/t)(k_1 \lambda_p)^2$$

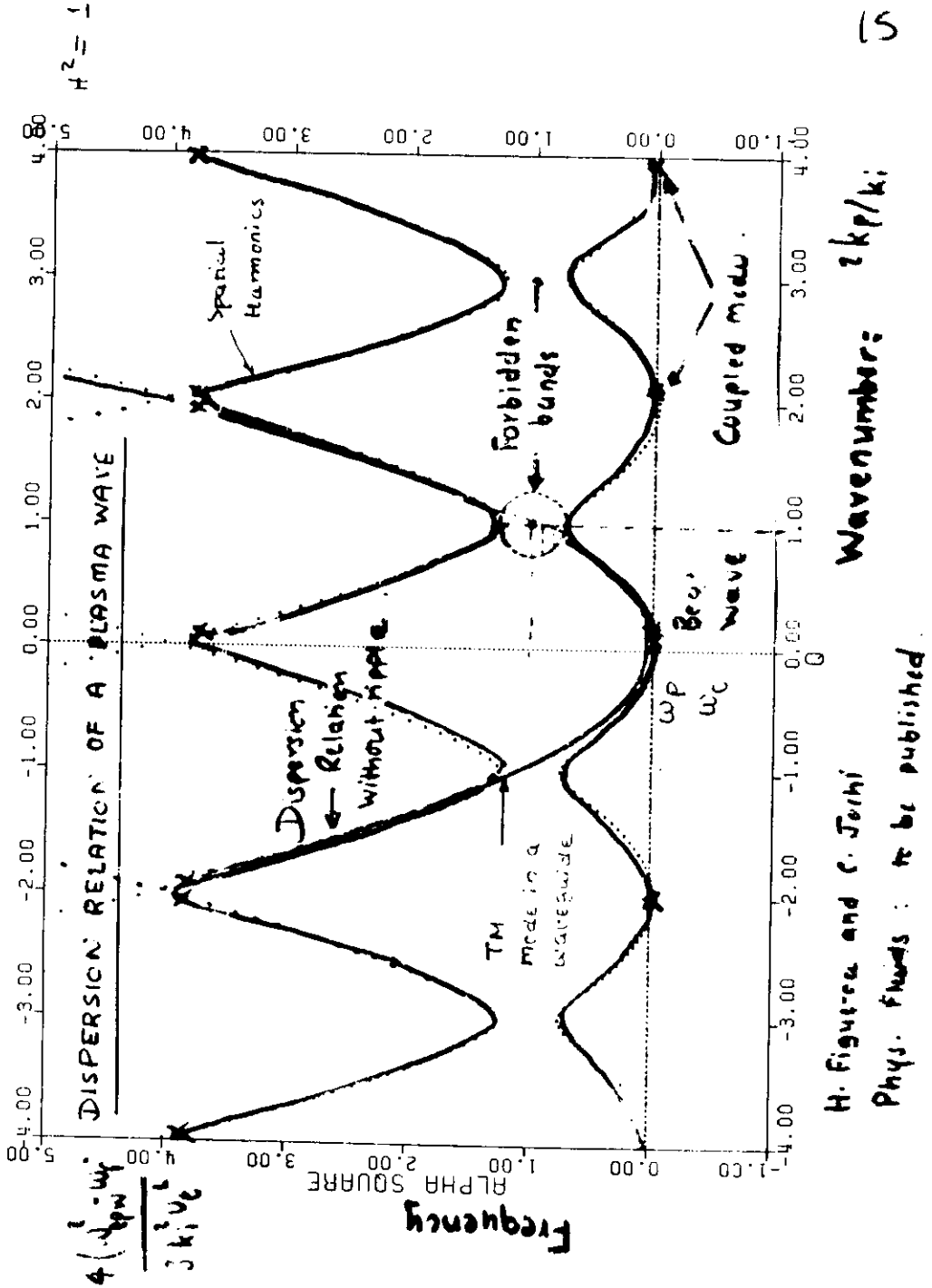
for $t = 4\%$, $p = 2$ Mode Coupling dominates $a < 0.04$

Numerical Solution for Beat Excitation in a Rippled Density showed Mode-Coupling.

Beat Wave Excitation

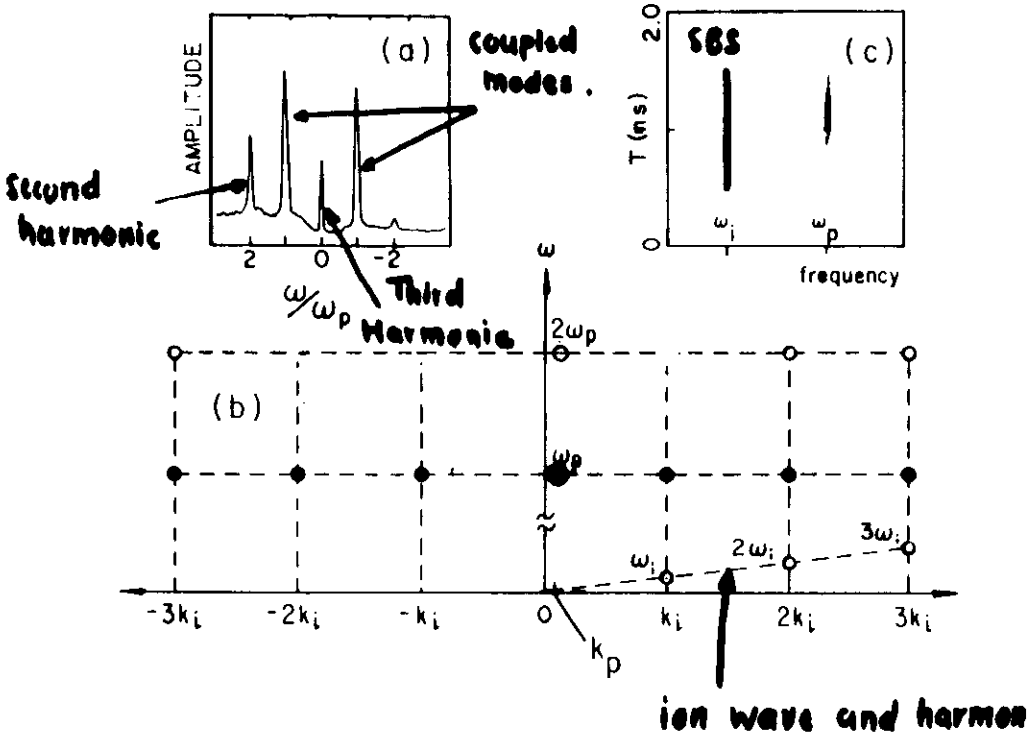


C. Barnes et al.
Phys. Rev. Lett. 54, 2629 (1985)



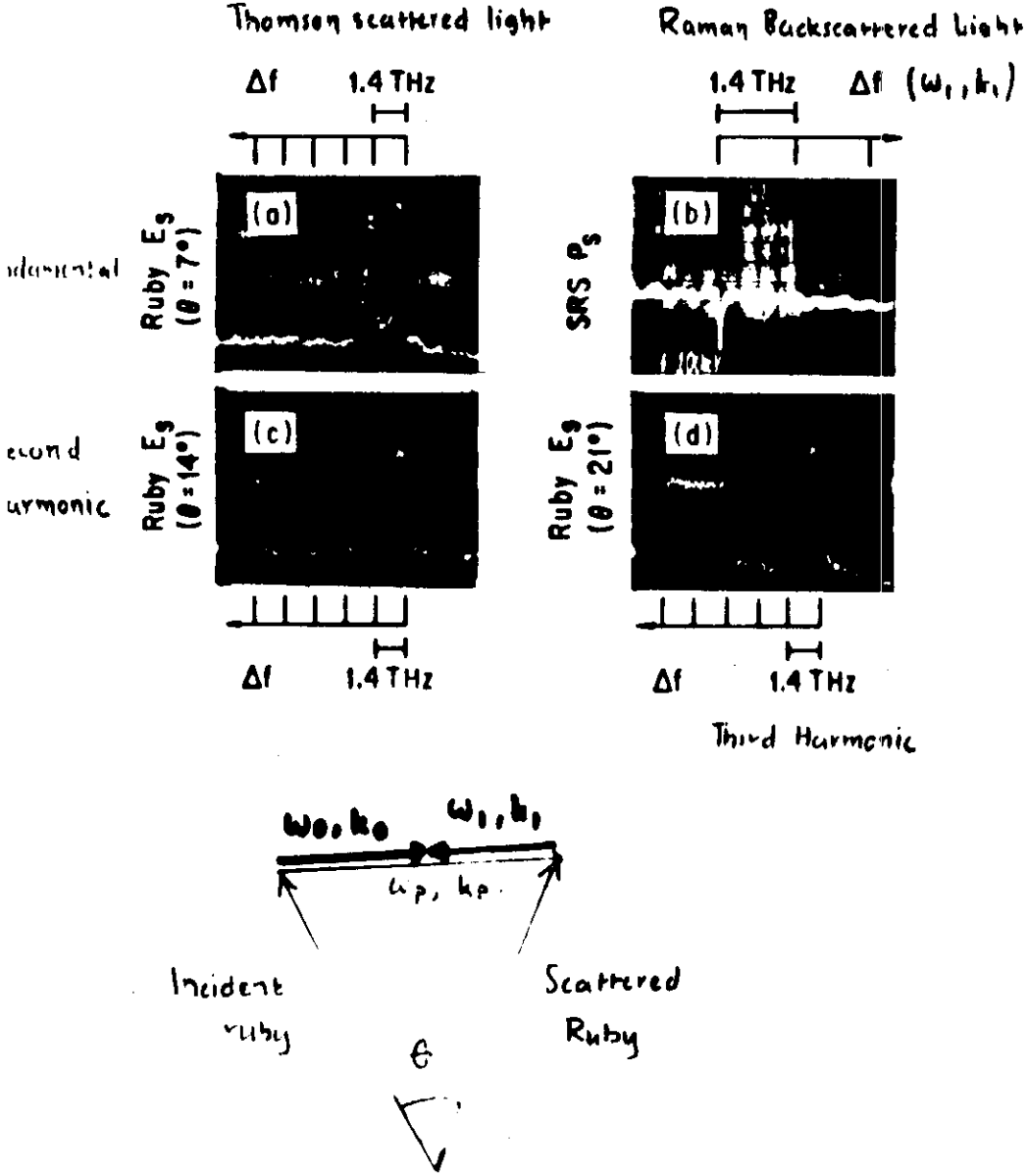
H. Figueroa and C. Joshi
Phys. Fluids : to be published

ELECTROSTATIC "2ω" : UCLA Expt.

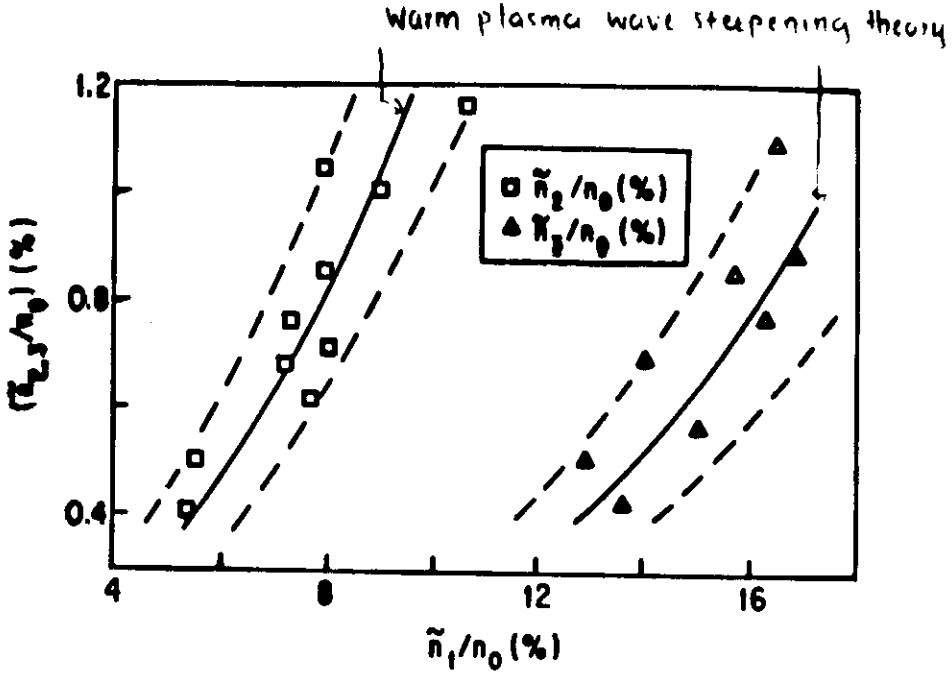


C. Darrow et. al.
Phys. Rev. Lett. 56, 2629 (1986)

Evidence for wave steepening



Plasma wave harmonics



$$\left(\tilde{n}_m / n_e\right) = \alpha_m \left(\tilde{n}/n_0\right)^m$$ — theory

$\alpha_2 = 1.5$
$\alpha_3 = 1.0$
} warm plasma

D. Umstadter et.al. Phys. Rev. Lett (to be published)

CONCLUSIONS.

1 Thomson Scattering is a powerful technique specially suited for probing collective fluctuations in a plasma.

2 Such collective ion and electron fluctuations are driven by various parametric processes : SRS, SBS, filamentation, $2\omega_p$ decay, PDI etc.

3 Much work remains to be done on the non-linear development of these instabilities and how these instabilities influence one another.

4. CAUTION:

Although basic physics is very interesting the study of PI's was primarily motivated by Laser fusion. These are no longer a problem when blue lasers are used.

: Phase conjugation, Chaos in strongly driven systems