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Measurement of the Synchrotron Radiation Spectrum from a Hot Plasma*

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The spectral distribtuion of the synchrotron radiation from a hot electron plasma has been measured. The plasma is confined in a magnetic-mirror configuration and heated by magnetic compression. The details of the experimental configuration have been previously described.[1] The synchrotron radiation measurements are performed using a far-infrared monochrometer with ten percent bandwidth followed by an InSb photodetector.[2] The time response of the system is limited to ten microseconds by the external electronics. The measurements here were made at a magnetic field of approximately 50 kG corresponding to a cyclotron wavelength of 2.14 mm. A typical oscilloscope trace of the output signal is given in Fig. 1 for a spectrometer setting corresponding to 1 mm. The initial spike is magnetic pickup. The magnetic field attains its peak value at 0.5 msec. and has a decay constant of 20 msec. Similar data were obtained over wavelengths from 4 mm to 0.2 mm.

In Figs. 2 and 3 the results of these measurements are given for times of 0.5 msec. and 1 msec., respectively. The experimental points shown are averages of three to six shots. Some typical error bars ($\pm\sigma$) are shown to indicate the variability from shot to shot. There is also variability of a longer time scale which does not appear in the error bars. The harmonic character of the radiation is clearly visable above the point-to-point variability. The frequencies at the harmonic minima correspond closely to the measured value of the peak magnetic field of 50 kG at 0.5 msec. and correspond to a lower value at 1 msec. which coincides with

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the field decay. The radiation intensity is compared with the theoretical curves for radiation from a Maxwellian distribution of noninteracting electrons from kT_e = 50 kev, 75 kev, and 100 kev plasmas. The time averaged temperature obtained from x ray pulse height analysis is kT_e = 70 kev.* The theoretical values are normalized to the 2nd harmonic of the experiment at each time. We conclude that our results are consistent with the basic theory of synchrotron radiation from a hot plasma, developed by Trubnikov,[3] Beard and Baker,[4] and others. The experimental spectrum indicates some additional structure not accounted for by the theory. The temperature, obtained from the synchrotron radiation measurements is time resolved, rather than averaged, and thus the rate of cooling of the plasma can be determined. We estimate the decrease of plasma temperature from the time of the first observation (Fig. 2) to the time of the second (Fig. 3) to be between 10 kev and 20 kev. Cooling as a result of synchrotron radiation has been calculated, and does not appear sufficient to account for the observed decrease in temperature.

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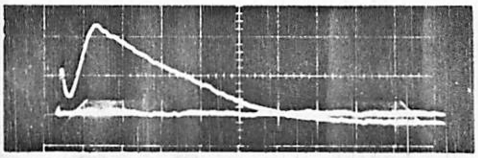
* This value of temperature is higher than that reported in Ref. 1.

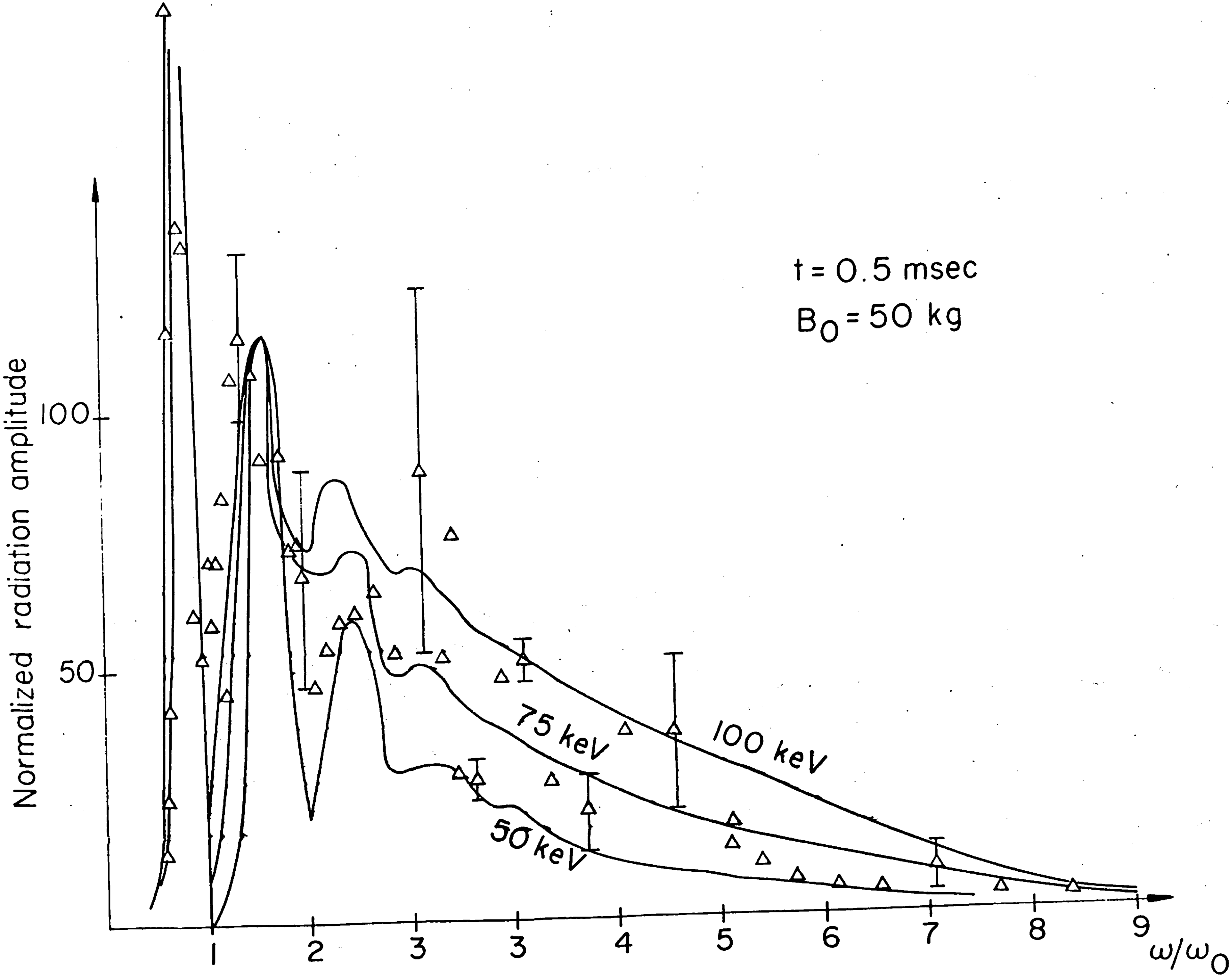
FIGURE CAPTIONS

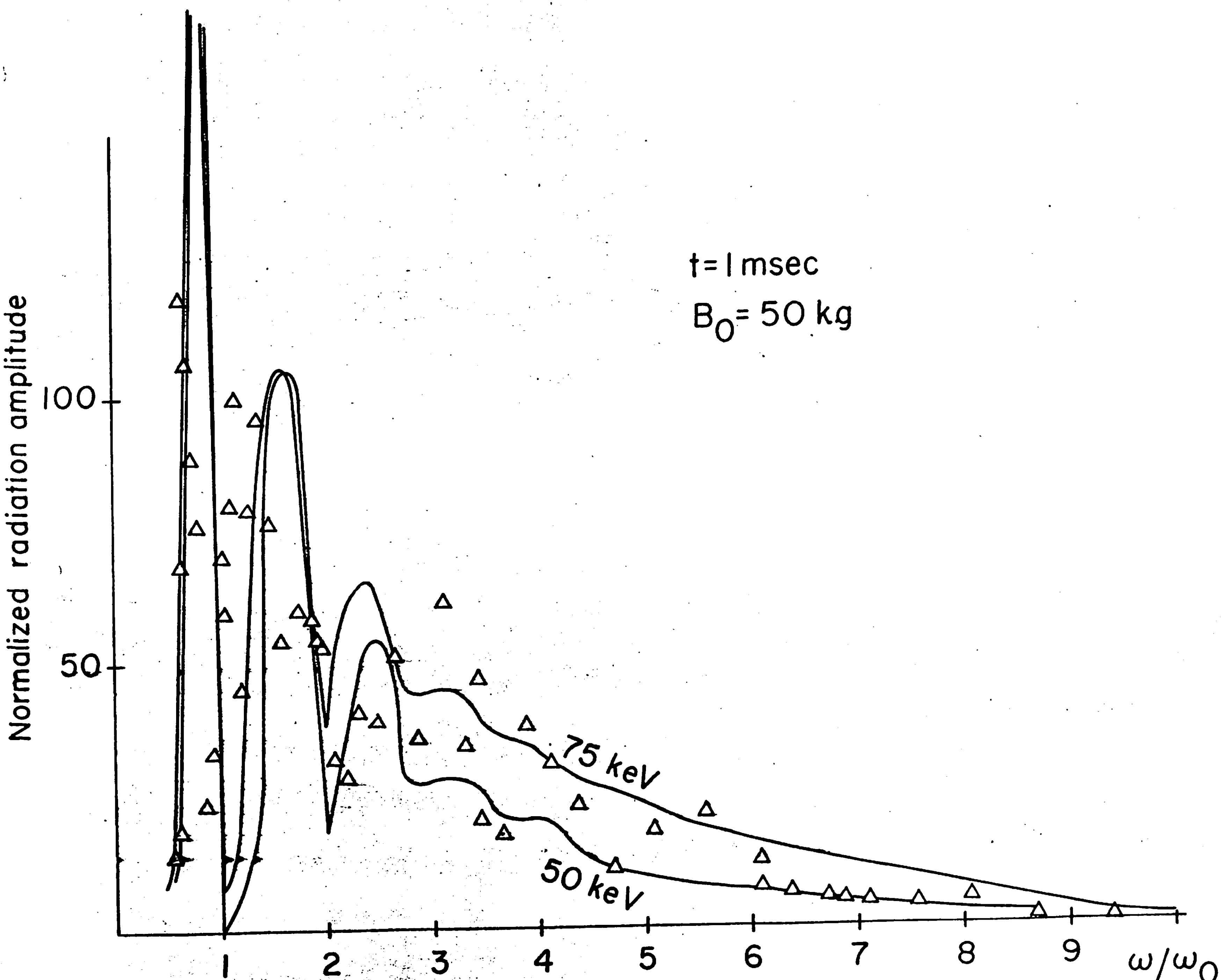
Fig. 1 Time resolved synchrotron radiation at 1 mm wavelength; sweep speed is 0.5 milliseconds per division.

Fig. 2 Synchrotron radiation spectrum at peak magnetic field.

Fig. 3 Synchrotron radiation spectrum 0.5 milliseconds after peak magnetic field.




t = 0.5 msec
B0 = 50 kg
Normalized radiation amplitude
100
50
1
2
3
3
4
5
6
7
8
9
ω/ω0
100 keV
75 keV
50 keV



t=1 msec
B0= 50 kg
Normalized radiation amplitude
100
50
75 keV
50 keV
1
2
3
4
5
6
7
8
9
ω/ω0