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MEASUREMENT OF THE SYNCHROTRON RADIATION SPECTRUM FROM A HOT PLASMA*

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The spectral distribution 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 monochromator with 10% bandwidth followed by an InSb photodetector.[2] The time response of the system is limited to 10 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.

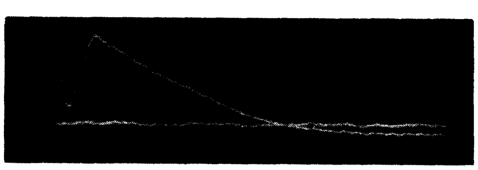

FIG. 1. Time-resolved synchrotron radiation at 1-mm wavelength; sweep speed is 0.5 millisecond per division.

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 visible above the point-to-point variability. The frequencies at the harmonic minima correspond closely to the

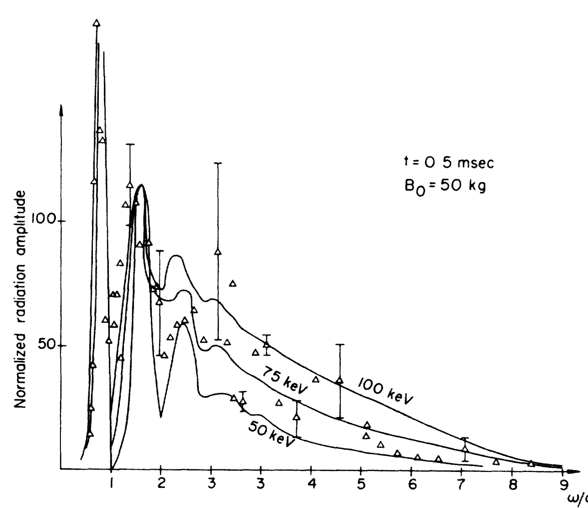

FIG. 2. Synchrotron-radiation spectrum at peak magnetic field.

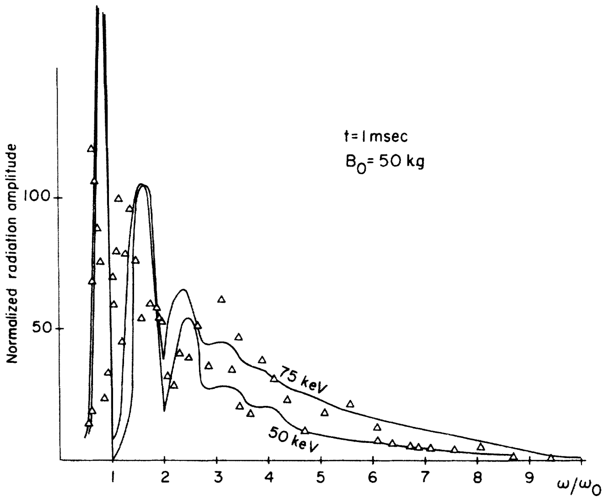

FIG. 3. Synchrotron-radiation spectrum 0.5 millisecond after peak magnetic field.

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 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 (this value of temperature is higher than that reported in reference 1). The theoretical values are normalized to the second 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 and Kudryavtev,[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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QUADRUPLE POINT OF He^3-He^4 MIXTURES*

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In this Letter we describe the results of strain-gauge measurements of the freezing curves of dilute mixtures of He^3 in He^4. At temperatures below about 0.37°K, these curves can have positive slopes, suggesting the existence of a quadruple point in agreement with the phase diagram proposed earlier by the authors.[1]

The apparatus is shown in Fig. 1. The sample chamber was a one-inch length of $\frac{1}{4}$-inch diameter, 0.006-inch wall, stainless steel tube filled with 1500 No. 40-AWG bare copper wires for efficient heat transfer. The strain gauge consisted of four feet of No. 40-AWG constantan wire wrapped noninductively around the middle of the stainless steel tube and fastened with household cement. A dummy gauge was wound on the copper frame to compensate for thermal effects. The difference in resistance between the sample strain gauge and the dummy gauge was measured with a modified Blake-Chase-Maxwell 32-cps bridge.[2] Cooling was provided by a He^3 refrigerator and a salt pill of 60 grams of potassium chrome alum embedded in castolite, a thermosetting plastic.[3] The primary tempera-

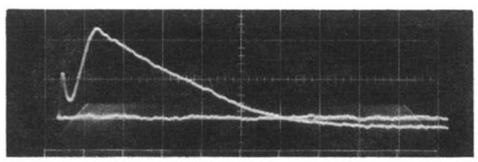

FIG. 1. Time-resolved synchrotron radiation at 1-mm wavelength; sweep speed is 0.5 millisecond per division.