§2. Validity Check of Thomson Scattering Diagnostic under Very Intense Plasma Radiation

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For many years, we have been worrying about the validity of the Thomson scattering (TS) data taken under very intense plasma radiation. Occasionally TS data shows peculiar electron temperature (*Te*) and density (*ne*) profiles like that shown in Fig. 1(A). Firstly we seriously considered them as physical realities, but soon conjectured that they are artifacts caused by the saturation of the avalanche photodiodes (APD) due to intense plasma radiation since they appear at the scattering positions that have diverter plates behind in the view scope. Even if no such structure appears, confidence of the deduced *Te* and *ne* from the data obtained under intense plasma radiation was our serious concern. In order to solve this problem to a large extent, we modified the TS diagnostic so that the DC levels (V_{DC}) of all APD (EG&G C30950 CD-1161) can be registered every 1ms. Each output of the APDs is connected to an input of the scanning ADC (NI 6625) via a 10 kΩ, which is necessary for preserving the impedance matching for short pulse circuit. With the V_{DC} thus obtain we can, in principle, judge whether an APD is operating in the normal condition. To facilitate this, we first examined the response of an APD to a 30ns-pulse light from a semiconductor-laser varying the intensity of continuous backlight from a tungsten lamp. We tested at two bias voltages: 0.9*Vr* and 0.5*Vr*, *Vr* being the recommended voltage that gives responsivity *Rp*= 675kV/W at 1060 nm. As shown in Fig. 2, the pulse output declines as the V_{DC} increases for both bias voltages. The behavior of the *Vb*=0.9*Vr* operation is partly explained by the voltage drop across the 100kΩ resistor, through which a high voltage is applied to the APD. But, the behavior of the *Vb*=0.5*Vr* operation seems to be somewhat different. We conjecture that the bandwidth *B* of the APD plus following circuit decreases as V_{DC} increases, thus reducing responsivity to a short pulse light. To check this, we measured the white noise *Vn* from the APD plus the following circuit as a function of V_{DC}, with the result shown in Fig.3. According to the noise theory, $< V_n^{\,2} > \propto I_{pe} B \propto B V_{DC}$. Here I_{pe} is the diode current, which is proportional to V_{DC}. This relation holds up to V_{DC}=0.5V for both bias voltages. The departure from the theoretical curves implies that *B* becomes smaller than needed for pulse-light detection when V_{DC} exceeds 0.5 V. Thus we come to a tentative and conservative criterion on the validity of the signals from APD: $V_{DC} \leqq 0.5$V. Most of the examined data for the outwardly shifted plasma, even for the highest density plasma ever observed, this criterion is met. On the other hand, for the inwardly shifted plasma, this criterion is often violated. The V_{DC} show in Fig.1(B) is much greater than 0.5V, thus *Te* and *ne* data are invalid.

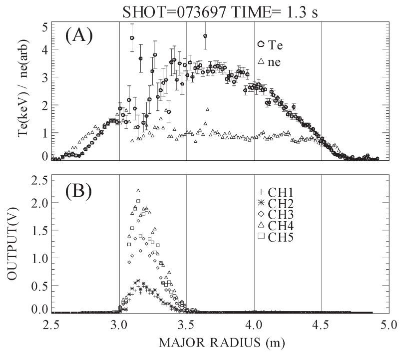
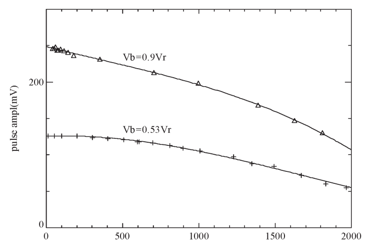
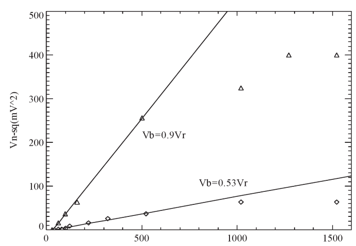


Fig. 1. Schematic drawing of the APD plus data acquisition system. The lower part enclosed by dashed line is newly installed.



V_{DC} (mV)

Fig. 2. Amplitude of 30ns-pulse-signal as a function of V_{DC} for V_b =0.9V_r and V_b =0.5V_r settings. Note that input light intensity is not exactly the same for the two measurements.



V_{DC} (mV)

Fig. 3. Square of wide band noise p-p voltage as a function of V_{DC} for V_b =0.9 V_r and V_b =0.53 V_r.