SHORT NOTES ON PLASMA PHYSICS

STANDARD DEFINITION

THE STANDARD DEFINITION OF A PLASMA IS AS THE 4TH STATE OF MATTER (SOLID, LIQUID, GAS, PLASMAS), WHERE THE MATERIAL HAS BECOME SO HOT THAT ELECTRONS (AT LEAST SOME) ARE NO LONGER BOUND TO INDIVIDUAL NUCLEI. ⇒ A PLASMA IS ELECTRICALLY CONDUCTING AND IT CAN EXIBIT COLLECTIVE DYNAMICS. ⇒ THE POTENTIAL ENERGY OF A PARTICLE WITH ITS NEIGHBORING PARTICLES IS WEAK COMPARED TO THEIR KINETIC ENERGY (OTHERWISE POSITIVE AND NEGATIVE PARTICLES - e^- AND +IONS - WOULD FORM A BOUN STATE.

THE SUBJECT IS VERY BROAD, INDEED AND IT INVOLVES TO BE DESCRIBED SEVERAL BRANCHES OF PHYSICS SUCH AS

- ELECTRODYNAMICS
- FLUIDDYNAMICS
- THERODYNAMICS
- STATISTICAL MECANICS
- FOR SOME SPECIAL PLASMA AT EXTREME CONDITI ALSO STROUG NUCLEI FORCES (QUARK-GLUON PLASM

OBSERVATION

A BROADER DEFINITION OF A PLASMA COULD INCLUDE MATTER WHICH IS ELECTRICALLY CONDUCTING EVEN IF THE WEAK-COUPLING APPROXIMATION DOESN'T HOLD. THERE IS ALSO A SPECIAL BRAUCH OF THE PLASMA PHYSICS THAT RELATE

THE PLASMA PHYSICS IN CONDENSE MATTER (PARTICULARLY SOLIDS) TO QUANTUM CONFINED SYSTEMS AND THEIR INTERACTION WITH E.M. WAVE. THE MODELING OF THESE MECHANISMS REQUIRES TO QUANTIZE THE PLASMA OSCILLATIONS OF CONDUCTING ELECTRONS IN MATERIALS EXCITED BY E.M. WAVES. THESE ARE ALSO REFERRED TO AS A "QUANTIZED PLASMA (CHARGE DENSITY) WAVES. TODAY THIS FIELD IS KNOWN AS PLASMA NANOSCIENCE.

HOWEVER, HERE WE WILL FOCUS ON THE CONVENTIONAL OR IDEAL LIMIT OF "WEAKLY-COUPLED PLASMAS".

- DEFINITION OF WEAK-COUPLING

WITH WEAK COUPLING WE MEAN WEAK FORCES ACTING AMONG NEAREST NEIGHBORING PARTICLES IN A PLASMA, IN ORDER TO GIVE A QUANTITATIVE MEANING TO THIS DEFINITION WE MUST DEFINE A TYPICAL DISTANCE AMONG NEIGHBOR PARTICLES. THIS IS GIVEN CONSIDERING A CUBE OF EDGE L_1 THAT CONTAINS ON AVERAGE 1 PARTICLES SUCH THAT $L_1^3 n \approx 1 \Rightarrow$ $L_1 \approx n^{-1/3}$, WHERE n IS THE PARTICLES DENSITY, THESE ARE PARAMETERS INVOLVED IN THE CALCULATION OF THE RATIO BETWEEN THE POTENTIAL ENERGY AND THE KINETIC ENERGY THAT IS NECESSARY TO DEFINE THE WEAK INTERACTION REGIME (NON-PERT.),

$$\frac{P.E.}{K.E} \approx \frac{eV}{\frac{1}{2}mV^2} \approx \frac{e^2/L_1}{\frac{1}{2}mV^2} \sim \frac{e^2 n^{1/3}}{T}$$

(T IS USUALLY MEASURED IN ENERGY UNITS IN

PLASMA PHYSICS BY SETTING $K_B = 1$.

FOR EXAMPLE FOR THE ITER PARAMETERS $T \sim 10\,keV$

$n \sim 10^{14}/cm^3 \Rightarrow P.E./K.E \sim 10^{-6}$.