Non-linear Extended Thermodynamics of Real Gases with Six Fields and its application to the Shock Wave Structure

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After the successful achievements of extended thermodynamics (ET) of rarefied monatomic gases [1] for many years, ET of rarefied polyatomic and dense gases has only recently been proposed and established [2]. The ET theory can explain the change of the types of the shock wave structure in a rarefied polyatomic gas from the nearly symmetric profile (Type A) to the asymmetric profile (Type B), and then further to the profile composed of thin and thick layers (Type C) as the Mach number increases from unity [3,4].

It should be emphasized that, for rarefied polyatomic gases where the dynamic pressure is much larger than other relaxation times, the shock wave structure can be analyzed satisfactory by using the simplest ET theory with 6 independent fields (ET6), that is, the mass density, the velocity, the temperature and the dynamic (non-equilibrium) pressure [4].

In the present talk, we present the non-linear ET6 theory that is valid even far from equilibrium and its application to the shock wave structure in a rarefied polyatomic gas [5,6]. In particular, the following points will be addressed:

1. The field equations of the non-linear ET6 theory of rarefied polyatomic gases are shown. The relationship between the ET6 theory and the Meixner theory is also discussed.
2. For small or moderately large Mach numbers, the shock wave structures based on the nonlinear and linear ET6 theories are substantially same.
3. Only for very large Mach numbers, difference between the linear and nonlinear ET6 exists but it is not so remarkable.
4. The non-equilibrium Meixner temperature may overshoot in contrast to the kinetic temperature.

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