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Allan N. Kaufman and Lennart Stenflo

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ACTION CONSERVATION IN THE PRESENCE OF A HIGH-FREQUENCY FIELD

Allan N. Kaufman

Physics Department and Lawrence Berkeley Laboratory
University of California, Berkeley, CA 94720, U. S. A.

and

Lennart Stenflo

Department of Plasma Physics
Umeå University
90187 Umeå, Sweden

August 1, 1974

ABSTRACT

Even in the presence of a high frequency field, which strongly modifies the plasma normal modes and their coupling coefficients, the Manley-Rowe condition for action conservation remains valid.

A fundamental property of three-wave interactions is the Manley-Rowe relation (MR), which states that for each quantum of action disappearing in the decay of the wave of highest frequency ω_3 , an equal quantum appears in each of the decay products, at frequencies ω_1 and ω_2 , with $\omega_3 \approx \omega_1 + \omega_2$.

There is as yet no completely general proof of MR , placing bounds on its domain of validity. Most calculations of three-wave interactions include a verification of its validity, with the implicit understanding that this serves as a check on the lengthy algebra preceding.

Among the studies on the validity of MR are the following:

1. It has been proved that Lagrangian systems satisfy MR .[1]

2. Hence a Lagrangian formulation[2] of the plasma dynamics of small amplitude waves serves to apply MR to such a system.

3. A Hamiltonian formulation of the perturbation expansion of the Vlasov-Maxwell system leads to MR .[3]

4. Further study of symmetry properties[4] provides insight into the conditions for MR .

5. Violation of MR is found for wave scattering by particles in the presence of catalytic waves which perturb particle orbits.[5]

Because of the consequences of MR for the evolution of a nonlinear system, it is important to test new situations for validity of MR . Such a new system is a plasma in the presence of a uniform finite amplitude electric field at a high frequency $\omega_0 \gg \omega_1$, ω_2 , ω_3 . This field serves to modify the normal modes and the wave coupling coefficients.[6] The detailed expressions given in Ref.6 can be used to test for MR . It is straightforward to do so; we have

found that MR is still exactly valid, even when the particle orbits, the modes, and the coupling strengths are greatly modified by the high frequency field.

We may conjecture from this result, together with those of Refs.2 and 3, mentioned above, that a Lagrangian or Hamiltonian formulation is still possible in the presence of a high-frequency pump. The oscillation-center canonical transformation[7] may lead to such a formulation.

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FOOTNOTES AND REFERENCES

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