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Continuity of generalized current

1 message

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There is a product rule of the following type: if φ is a scalar valued function and F is a vector field, then

$$\operatorname{div}(\varphi \mathbf{F}) = \operatorname{grad}(\varphi) \cdot \mathbf{F} + \varphi \ \operatorname{div}(\mathbf{F}),$$

or in more suggestive notation

$$\nabla \cdot (\varphi \mathbf{F}) = (\nabla \varphi) \cdot \mathbf{F} + \varphi \, (\nabla \cdot \mathbf{F}).$$

AND

Fluid dynamics [edit]

***See also:* Mass flux *and* Vorticity equation**

In fluid dynamics, the continuity equation states that, in any steady state process, the rate at which mass enters a system is equal to the rate at which mass leaves the system.[1][2]

The differential form of the continuity equation is:[1]

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0$$

where

- ρ is fluid density,
- t is time,
- u is the flow velocity vector field.

In this context, this equation is also one of Euler equations (fluid dynamics). The Navier–Stokes equations form a vector continuity equation describing the conservation of linear momentum.

If ρ is a constant, as in the case of incompressible flow, the mass continuity equation simplifies to a volume continuity equation:[1]

$$\nabla \cdot \mathbf{u} = 0,$$

which means that the divergence of velocity field is zero everywhere. Physically, this is equivalent to saying that the local volume dilation rate is zero.

Energy and heat [edit]

Conservation of energy says that energy cannot be created or destroyed. (See below for the nuances associated general relativity.) Therefore there is a continuity equation for energy flow:

$$\frac{\partial u}{\partial t} + \nabla \cdot \mathbf{q} = 0$$

where

- u = local energy density (energy per unit volume),
- q = energy flux (transfer of energy per unit cross-sectional area per unit time) as a vector,

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