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Can the society be simulated as plasma fluid?

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Abstract

Both society and plasma (ionized gas) fluid are composed of active, interactive, and free, individuals. These individuals response to any internal and external effects (fields for plasma), and exhibit collective behaviour. According to this structure, there are a wide range of similarities between the plasma fluid and the society. The nature of fluidity of plasma arises from the interaction of its free interactive charges, so the society may behave as a fluid owing to the free interactive individuals (persons). This fluid model may explain many social phenomena like social instability, diffusion, flow, viscosity...So the society behaves as a sort of intellectual fluid. It may be possible to suggest a modification of plasma computation simulation technique to study the social phenomena.

1. Introduction

Picture of Holism and Individualism in social science is quiet similar to that of the fluid physics (of particle and fluid models). Connection between holism and individualism is improved via computer simulation techniques, and this modern technique is quite familiar in modern computational physics. Many sociology researches adopt the concept of mechanical fluid in computational social simulation, especially in crowed phenomenon.

The fluid is a continuous medium this characteristic features is found in sociology as well like *social fluid* (Muller and Pollak , 2001) or the *unstable social fluid* (Kaplan,1994). Not just the terminology of fluid is used in modern sociology but many other relevant terms of fluid dynamics like diffusion, mobility, instability, bunch…etc. The usage of these terms of fluid dynamics in sociology does not mean that the theoretical logic of fluid dynamic controls that medium (society). These terminologies are scattered arbitrary in different research articles without mathematical unification (logic) as that of fluid dynamics. The concept of physical fluid may not fit the simulation of society very well, or it has a quite limited validity and may needs modifications. Fluid state does not exhibit *collective behaviour* (Chen, 1984), which is one of the important features of society.

In modern physics, the forth state of matter or the plasma exhibits *collective behaviour* may have rather similar behaviour of the society. The plasma scientist D. Bohm (1917-1992) saw

in plasma a model of society (Wilkins,1986), but he did not go in deep. In this article, this model is considered.

2. The Plasma

The plasma is the fourth state of matter, and may be defined as an ionized gas composed of charged and neutral particles that exhibit a quiseneutrality and collective behaviour. Macroscopically the plasma looks as a sort of fluid called MagnetoHydroDynamic (MHD) fluid, whereas microscopically the plasma is considered as a grope of free charged and neutral particles and obey the statistical kinetic theory (Chen, 1984).

The plasma fluid has more other properties than those of ordinary fluid like collective behavior, shielding, high response for external effects of fields like electric and magnetic fields, and diffusion through a confining field. These properties arise owing to the charged structure of the plasma, and the rather free units (free charged particles).

Using terminology of sociology (Aisted and Radgivning 2001), one can distinguish three levels in plasma: micro, meso, and macro. Micro level is for the individual electrons and ions (particle viewpoint); the meso level may represent the groups of particles in a scale of Debye length (Debye Sphere), and the macro level is for the system consideration and according to this level the plasma looks as a continuous medium such as fluid.

2.1 Plasma and society

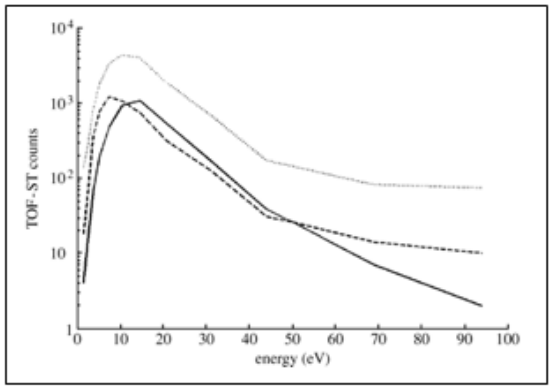
Both society and the plasma fluid are composed of active, interactive, and free, individuals. These individuals are responded to any internal and external effects, and exhibit collective behaviour. According to this structure, there are a wide range of similarities between the plasma fluid and the society.

Any member of the society is socialized, and the plasma unit (member) is ionised. Within these features the member can do its role in the system. The members of society interact with each other within societal interaction (conducting, cooperation, conflict ...etc.), whereas plasma's members interact within electromagnetic interaction, and collision of many types. The society members are controlled by many types of social controls; and the plasma members are controlled by confinement system (magnetic or electrostatic fields). Both systems (society and

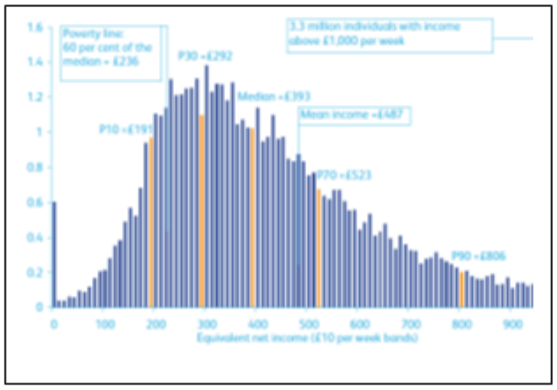
plasma) exhibit collective behaviour, and there are many other relatively common features. The plasma can be considered through four different models, those are single particle, fluid model, kinetic theory, and computational model.

However, one can say that:

1-There are similarity in nature of structure of both of them (high population, random like behaviour of individuals, high interactivity of the units and the system, sub structures, the need for control system or confinement, defence or shielding behaviour, so many types of acting forces …etc.). Figures (1) and (2) show some similarities.

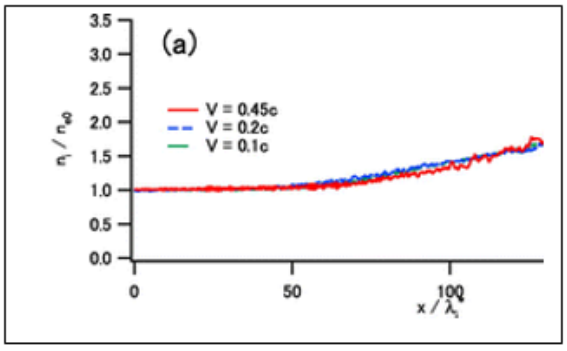


Energy distribution for ions (Michael, M. *et al*. 2005)

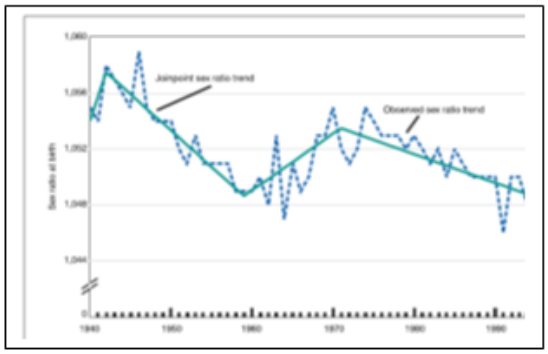


Equivalent net income, UK 2007-08. Number of individuals with income in each range (millions). (Hills, J. et al. 2010)

Fig. 1 comparison of energy distribution of plasma (ions) and the income distribution for a society.



The ratio of ion density to electron density in unmagnatized plasma, which is around one (Kato, and Takabe, 2008)



Sex ratio at berth in USA, which is around one (1940-2002). (Mathews, *et al*. 2005)

Fig.2 Comparisons of the charge neutrality of plasma with gender ratio of a society.

2- Both systems can be studied macroscopically and microscopically.

3- Both systems exhibit some similar behaviour.

These and other similarities led plasma scientist David Bohm to see in plasma a model of society (Wilkins, 1986).

3. Instability and Social Change

In fluid dynamics, the forces that controlling the behaviour of fluid arise in many types, like viscosity, gravitational attraction, difference of pressure, surface tension, elasticity, and so on. The force that makes the fluid under equilibrium (it means that the total force those affecting the fluid is zero) is equal to the total force (resultant) but in opposite direction and may be called the Inertia force**.**

There are many ratios of the inertia force to one of the acting forces. Each ratio has a certain name (like Reynolds, Froude, Weber, and Mach numbers) and a certain role in fluid dynamics. For example Reynolds number is the ratio of inertia force to the viscosity force. The viscosity is a property of fluid by which it resists shape change or relative motion within itself. Reynolds number has a critical value. When Reynolds number is smaller than the critical value the fluid is in stable state (laminar flow) whereas in case of that it is larger than the critical value, there will be a turbulent state. The turbulence is a departure from equilibrium state, and this instability may be damped (stable equilibrium) or grown (unstable equilibrium). The concept of free energy may be used to describe the state of instabilities. In case of there is no external effect (endothermic) that may enhance the turbulence and the turbulence will be damped, other wise (exothermic) the turbulence will be grown.

In social studies, Weaver (Weaver1993) studied the interaction between the forces in social change. In a previous work, there was an attempt to use the concept of plasma instability to ascribe the social change (Sanduk 2000).

The acting forces in the society are political, economical, religious, foreign (external), ethical, tribal, and so on. Interesting thing in this type of medium is the large number of the acting forces. This can lead to a critical equilibrium (or a fragile equilibrium). The total effect of these forces may be regarded as Inertia force of society. The solidarity (mechanical or organic solidarity according to Durkheim or any types) act as the bound that constructs the system, accordingly the system resists any attempt of change. That may form the viscosity of society (*social ties*). As an example, the foreign communities (Chinese, African, Islamic…etc.) in western society exhibit a high viscosity. These communities look like drops of oil or honey in water

(low viscose fluid). Therefore, each society has its own viscosity, which it depends on the factors of solidarity (tribal relationship, religion solidarity,…etc). As the solidarity is changed with time, the social viscosity may be changed as well.

4. Diffusion and the Control System

The diffusion may be defined as the gradual mixing of different gases or liquids placed in mutual contact due to the random thermal motion of their constituent particles (Yule, 1985). This is the classical type of diffusion in fluid. It depends on the gradient of an accumulation (variation of population or density in a space) in certain region and may be responsible for the movement of fluid from one place to another.

In Myers (2001) model of social diffusion processes, the gradient is quite clear. Since the early work of Pemberton (1938) about social diffusion (The spatial order of culture diffusion) one can find the concept of location (spatial) with the diffusion; which is involved as the concept of gradient in fluid dynamics. The diffusion of social fluid may appear in many forms such as occupation, or as religious, ideology, culture separation. Transferring of technology may obey the same law of diffusion. This model may explain the expansion of empires, holy wars, export of revolutions…etc.

In addition to the classical type of diffusion there many types of diffusions in plasma physics. The controlling system (external magnetic field for plasma) will adjust or limit the activities of the individuals (charged particles) within an acceptable range, and that leads to a good confinement system. But there is a limit for increasing the control forces. The magnetic field that exceeds a certain limit acts in reversal manner. It will destabilize the plasma. Instability will arise in the system and some of these particles will leave the system (diffusion). This phenomenon is will known in plasma physics, and the associated diffusion is called Bohm diffusion. This is an anomalous diffusion, and appears in plasma fluid (interactive fluid) only. It is a sort of mechanism of restoring stability.

The turbulence in a society after imposing more restricting laws or obstructions is quite familiar phenomena. In any strongly dictated society there is a sort of internal instability that leads to phenomena of desertion, which is a diffusion from society (fluid) to another society (fluid). After desertion, the system will be more stable!

5. Intellectual fluid model

The nature of fluidity of plasma arises from the interaction of its free interactive charges, so as the society may behave like a fluid owing to its free interactive individuals.

In physics, the equation of fluid dynamics is a modified equation of motion of single particle. This equation is Navier- Stokes equation:

$$\rho\left[\frac{d\boldsymbol{u}}{dt}+\boldsymbol{u}\cdot\nabla\boldsymbol{u}\right]=\nabla\cdot\boldsymbol{\sigma}+\boldsymbol{f}$$

where ρ denotes the density of the fluid, $\boldsymbol{u}$ is the velocity, $\nabla\cdot\boldsymbol{\sigma}$ the shear stress, and $\boldsymbol{f}$ is all other forces. In this equation, there is no effect of the collective behaviour. For plasma case, this equation is modified to include the effective internal forces. These forces raise from the mutual interaction between the charged particles. The above equation is modified to be (Chen, 1984):

$$\rho\left[\frac{d\boldsymbol{u}}{dt}+(\boldsymbol{u}\cdot\nabla)\,\boldsymbol{u}\right]=qn(\boldsymbol{E}+\boldsymbol{u}\times\boldsymbol{B})+\boldsymbol{f_p}$$

Where q is the charge, $\boldsymbol{E}$ is the electric field, $\boldsymbol{B}$ is the magnetic field, n is the plasma density, and $\boldsymbol{f_p}$ is the pressure, and collisions forces. These forces generated by plasma particles and these particles are subjects for these forces as well.

In analogy to those types of forces, the acting social forces may be considered. However, there are many attempts to consider formulation mathematical models for society (Beltrami , 2001 or Malcolm, 1975). Plasma computer simulation (Birdsall, & Langdon, 1985) is a powerful technique to study this complicated structure, and may be modified to module the society as well.

As shown above, the plasma fluid model for society may explain many social phenomena like social instability, social diffusion, social flow, social viscosity... The acting forces is related to intelligent units with free will, so the society may be considered as a sort of *intellectual fluid*.

6. Conclusions

1-Macroscopically, the society looks as a sort of a continuous medium. It is a complicated (interactive) fluid likes the plasma. Microscopically, it is composed of free (free will) interactive units (individuals).

2-The society may behave in some way as that of MHD fluid mechanic; then it may be, compressed, diffused, fluctuated, influenced by rumour, culture or any information media, confined, …etc. This fluid is intellectual human fluid.

3-Some social phenomena like instability, diffusion, etc. may be attributed to the nature of the interactive medium.

4-The MHD fluid model is more appropriate to simulate many social phenomena.

5- Similar to plasma simulation computational technique, a new model can be used to study the society.

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