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4-Point Correlations of Dusty Fluid MHD Turbulent Flow in a 1st order Chemical-Reaction

By M. A. Bkar Pk, Abdul Malek & M. A. K. Azad
University of Rajshahi, Bangladesh

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4-Point Correlations of Dusty Fluid MHD Turbulent Flow in a 1st order Chemical-Reaction

M. A. Bkar Pk [α], Abdul Malek [σ] & M. A. K. Azad [ρ]

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I. Introduction

Chemical reaction as used in chemistry, chemical engineering, physics, fluid mechanics, heat and mass transport. The mathematical models that describe chemical reaction kinetics provide chemists and chemical engineers with tools to better understand and describe chemicals processes such as food decomposition, stratospheric ozone decomposition, the complex chemistry of biological systems and MHD turbulence. In recent year, the motion of dusty viscous fluids has developed rapidly. The motion of dusty fluid occurs in the movement of dust – laden air, in problems of fluidization, in the use of dust in a gas cooling system and in the sedimentation problem of tidal rivers. The behavior of dust particles in a turbulent flow depends on the concentrations of the particles and the size of the particles with respect to the scale of turbulent fluid. Kishore and Golsefid [1, 1988] obtained and expression for the effect of Coriolis force on acceleration covariance in MHD turbulent flow of a dusty incompressible fluid. Kumar and Patel [2, 1974] derived expressions the first order reactant in homogeneous turbulence before the final period of decay. Kumar and Patel [3, 1975] also studied the first order reactant in homogeneous turbulence before the final period for the case of multi-point and multi-time. Chandrasekhar [4, 1951] obtained the invariant theory of isotropic turbulence in magneto-hydrodynamics. Corrsin [5, 1951] established on the spectrum of isotropic temperature fluctuations in isotropic turbulence. Bkar PK *et al.*,[6,2012]calculated for the first-order reactant in homogeneous dusty fluid turbulence prior to the ultimate phase of decay for four-point correlation in a rotating system. Sarker *et al.,* [7, 2012] discussed the homogeneous dusty fluid turbulence in a first-order reactant for the case of multi point and multi time prior to the final period of decay. Bkar Pk *et al.*, [8, 2013] also established the homogeneous turbulence in a first-order reactant for the case of multi point and multi time prior to the final period of decay in a rotating system. Bkar Pk *et al.*,[9, 2014]further enlarge the previous problem for the first-order reactant of homogeneous dusty fluid turbulence prior to the final period of decay in a rotating system for the case of multi-point and multi-time at four-point

Author α σ ρ: Department of Applied Mathematics, University of Rajshahi, Bangladesh.

Ref

1. N. Kishore and Y.T. Golsefid, Effect of coriolis force on acceleration covariance in MHD turbulent flow of a dusty incompressible fluid. Astrophysics and Space Sciences (Astr. Space Sci.) 150, 89-101 (1988). http://dx.doi.org/10.1007/BF00714156

correlation. Sarker and Kishore [10, 1991] studied the decay of MHD turbulence before the final period. Bkar Pk *et al.*, [11, 2012] discussed the decay of energy of MHD turbulence for four-point correlation. Bkar Pk *et al.*, [12, 2013] also pointed out that the decay of MHD turbulence prior to the ultimate phase in presence of dust particle for four-point correlation. Bkar Pk *et al.*, [13, 2013] further calculated the decay of dusty fluid MHD turbulence for four-point correlation in a rotating system. Sarker and Islam [14, 2001] obtained the decay of dusty fluid MHD turbulence before the final period in a rotating system. Sarker and Ahmed [15, 2011] pointed out that the fiber motion in dusty fluid turbulent flow with two point correlation. Dixit and Upadhyay [16, 1989] obtained the effect of Coriolis force on acceleration covariance in MHD turbulent dusty flow with rotational symmetry. Azad *et al.* [17, 2011] studied the statistical theory of certain distribution functions in MHD turbulent flow for velocity and concentration undergoing a first order reaction in a rotating system. Islam and Sarker [18, 2001] studied the first order reactant in MHD turbulence before the final period of decay for the case of multi-point and multi-time. Bkar Pk *et al.*, [19,2015] discussed the effects of first-order reactant on MHD turbulence at four-point correlation. Deissler [20, 21 1958, 1960] developed a theory 'On the decay of homogeneous turbulence before the final period.' Sengupta and Ahmed [22, 2014] studied the MHD free convective chemically reactive flow of a dissipative fluid with thermal diffusion, fluctuating wall temperature and concentrations in velocity slip regime. Mukhopadhyay [23, 2013] obtained the chemically reactive solute transfer in MHD boundary layer flow along a stretching cylinder with partial slip. Azad et al., [24, 2010] discussed first order reactant in magneto-hydrodynamic turbulence before the final Period of decay in presence of dust particles. Poornima and Bhaskar Reddy [25, 2013] investigated the effects of thermal radiation and chemical reaction on MHD free convection flow past a semi-infinite vertical porous moving plate.

For first order chemical reaction, most of the author has been discussed their problems in two and three point correlation and some author has been done in a porous moving plate. Bkar PK *et al.*, has been investigated their problems for MHD turbulence with the present of dust particles, rotating systems, dust particles in rotating systems and first order chemical reaction for point correlation.

To the best of author's knowledge, the interaction between dusty fluid MHD turbulence and first order chemical reaction at four point correlations has received little attention. Hence in our present paper we have studied the decay of dusty fluid MHD turbulence in a first order chemical reaction for four-point correlation. The expressions for the fluctuation of velocity components and concentration have been obtained and effects of chemical reactions have been computed numerically and discussed in detail. Finally we have obtained the decay of dusty fluid of magnetic energy fluctuation of concentration undergoing a first order chemical reaction for four-point correlation in the form

$$\frac{\langle h^2\rangle}{2}=\left(AT_0^{\frac{-3}{2}}+BT_0^{-5}\right)\exp(-RT_0)+\left(CT^{\frac{-15}{2}}+DT^{\frac{-17}{2}}\right)\exp\{(-R+M)T\}.$$

where R is the chemical reaction, M is the dust particle parameter, $\langle h^2\rangle$ denotes the total energy that is, mean square of the magnetic field fluctuation, t is the time, and A , B, C, D, t_0 and t_1 are arbitrary constants determined by the initial conditions.

II. Two-Point Correlation and Spectral Equations-

First we discussed two and three point correlations with spectral equations in briefly next calculated our main problem elaborately. Induction equation at the point P and the corresponding equation for the point P' in the magnetic are given by

Ref

11. M. A. Bkar. PK,M. A. K. Azad and M.S.Alam Sarker. Decay of energy of MHD turbulence for four-point correlation. International Journal of Engineering Research and Technology.1(9): pp 1-13. 2012.

$$\frac{\partial h_i}{\partial t}+u_k\frac{\partial h_i}{\partial x_k}-h_k\frac{\partial u_i}{\partial x_k}=\left(\frac{\nu}{p_M}\right)\frac{\partial^2 h_i}{\partial x_k\partial x_k}, \quad (1)$$

$$\frac{\partial h'_j}{\partial t}+u'_k\frac{\partial h'_j}{\partial x'_k}-h'_k\frac{\partial u'_j}{\partial x'_k}=\left(\frac{\nu}{p_M}\right)\frac{\partial^2 h'_j}{\partial x'_k\partial x'_k}. \quad (2)$$

Notes

Multiplying equation (1) by h'_j (2) by h_i,adding and taking ensemble average and using

$$\frac{\partial}{\partial r_k}=-\frac{\partial}{\partial x_k}=\frac{\partial}{\partial x'_k},$$

with the relations

$$\left\langle u_k h_i h'_j\right\rangle=\left\langle -u'_k h_i h'_j\right\rangle,\left\langle u'_j h_i h'_k\right\rangle=\left\langle -u_i h_k h'_j\right\rangle$$

we get

$$\frac{\partial}{\partial t}\left\langle h_i h'_j\right\rangle+2[\frac{\partial}{\partial r_k}\left\langle u'_k h_i h'_j\right\rangle-\frac{\partial}{\partial r'_k}\left\langle u_i h_k h'_j\right\rangle]=2\left(\frac{\nu}{p_M}\right)\frac{\partial^2}{\partial r_k\partial r_k}\left\langle h_i h'_j\right\rangle, \quad (3)$$

Interchanging the points p and p' with indices i and j, then taking contraction of the indices i and j, we get the spectral equation corresponding to two point correlation is

The spectral equation corresponding to the two point correlation equation taking contraction of the indices is

$$\frac{\partial}{\partial t}\left\langle \varphi_i\varphi'_i(\hat{k})\right\rangle+\frac{2\nu}{p_M}k^2\left\langle \varphi_i\varphi'_i(\hat{k})\right\rangle=2ik_k[\left\langle \alpha_i\varphi_k\varphi'_i(\hat{k})\right\rangle-\left\langle \alpha_k\varphi_i\varphi'_i(-\hat{k})\right\rangle] \quad (4)$$

where,

$\varphi_i\varphi'_i$ and $\alpha_i\phi_k\phi'_i$ are defined by

$$\left\langle h_i h'_i(\hat{r})\right\rangle=\int_{-\infty}^{\infty}\left\langle \varphi_i\varphi'_i(\hat{k})\right\rangle\exp[i(\hat{k}.\hat{r})]d\hat{k} \quad (5)$$

$$\left\langle u_i h_i h'_i(\hat{r})\right\rangle=\int_{-\infty}^{\infty}\left\langle \alpha_i\varphi_k\varphi'_i(\hat{k})\right\rangle\exp[i(\hat{k}.\hat{r})]d\hat{k} \quad (6)$$

and $\left\langle u'_k h_i h'_i\right\rangle=\left\langle u_k h_i h'_i(-\hat{r})\right\rangle=\int_{-\infty}^{\infty}<\alpha_k\varphi_i\varphi'_i(-\hat{k})>\exp(i\hat{k}.\hat{r})d\hat{k}.$

III. Three-Point Correlation and Spectral Equations-

We take momentum equation of MHD turbulence at the point p, and the induction equations in the magnetic field at the and p'' as

$$\frac{\partial u_l}{\partial t}+u_k\frac{\partial u_l}{\partial x_k}-h_k\frac{\partial h_l}{\partial x_k}=-\frac{\partial W}{\partial t}+\nu\frac{\partial^2 u_l}{\partial x_k\partial x_k}, \quad (7)$$

$$\frac{\partial h'_i}{\partial t}+u'_k\frac{\partial h'_i}{\partial x'_k}-h'_k\frac{\partial u'_i}{\partial x'_k}=\left(\frac{\nu}{p_M}\right)\frac{\partial^2 h'_i}{\partial x'_k\partial x'_k}, \quad (8)$$

$$\frac{\partial h''_j}{\partial t}+u''_k\frac{\partial h''_j}{\partial x''_k}-h''_k\frac{\partial u''_j}{\partial x''_k}=\left(\frac{\nu}{p_M}\right)\frac{\partial^2 h''_j}{\partial x''_k\partial x''_k}. \tag{9}$$

We multiplying equation (7) by $h'_i h''_j$, (8) by $u_l h''_j$,and (9) by $u_l h'_i$, then adding and taking ensemble average and using

$$\frac{\partial}{\partial x'_k}=\frac{\partial}{\partial x'_k},\ \frac{\partial}{\partial r'_k}=\frac{\partial}{\partial x''_k},\ \frac{\partial}{\partial x_k}=-(\frac{\partial}{\partial r_k}+\frac{\partial}{\partial r'_k})$$

and interchanging of points p' and p'', in the subscript i and j, with the relations

$$\langle u_l u''_k h''_j h'_i\rangle=\langle u_l u'_k h'_i h'_j\rangle \text{ and } \langle u_l u''_j h_j h'_i\rangle=\langle u_l u_k h_i h''_k\rangle .$$

After simplifying the obtained results and then using Fourier transforms as

$$\langle u_l h'_i(\hat r)h''_j(\hat r')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle \phi_l\beta'_i(\hat k)\beta''_j(\hat k')\rangle \exp[i(\hat k.\hat r+\hat k'.\hat r')d\hat k d\hat k', \tag{10}$$

$$\langle u_l u'_k(\hat r)h'_i(\hat r)h''_j(\hat r')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle \phi_l\phi'_k(\hat k)\beta'_i(\hat k)\beta''_j(\hat k')\rangle \exp[i(\hat k.\hat r+\hat k'.\hat r')d\hat k d\hat k', \tag{11}$$

$$\langle u_l u'_i(\hat r)h'_i(\hat r)h''_j(\hat r')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle \phi_l\phi'_i(\hat k)\beta'_i(\hat k)\beta''_j(\hat k')\rangle \exp[i(\hat k.\hat r+\hat k'.\hat r')d\hat k d\hat k', \tag{12}$$

$$\langle u_l h'_i(\hat r)h''_j(\hat r')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle \phi_l\beta'_i(\hat k)\beta''_j(\hat k')\rangle \exp[i(\hat k.\hat r+\hat k'.\hat r')d\hat k d\hat k', \tag{13}$$

$$\langle u_l h_k(\hat r)h'_i(\hat r)h''_j(\hat r')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle \phi_l\beta_k(\hat k)\beta'_i(\hat k)\beta''_j(\hat k')\rangle \exp[i(\hat k.\hat r+\hat k'.\hat r')d\hat k d\hat k', \tag{14}$$

$$\langle w h'_i(\hat r)h''_j(\hat r')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle \gamma\beta'_i(\hat k)\beta''_j(\hat k')\rangle \exp[i(\hat k.\hat r+\hat k'.\hat r')d\hat k d\hat k'. \tag{15}$$

we get

$$\frac{\partial}{\partial t}\left(\overline{\phi_l\beta'_i\beta''_j}\right)+\frac{\nu}{p_M}[(1+p_M)(k^2+k'^2)+2p_M kk'+R]\left(\overline{\phi_l\beta'_i\beta''_j}\right)=$$

$$i(k_k+k'_k)(\overline{\phi_l\phi_k\beta'_i\beta'_j})-i(k_k+k'_k)(\overline{\beta_l\beta_k\beta'_i\beta'_j})-i(k_k+k'_k)(\overline{\phi_l\phi'_k\beta'_i\beta'_j})$$

$$+i(k_k+k'_k)(\overline{\phi_l\phi'_i\beta'_k\beta'_j})+i(k_l+k'_l)(\overline{\gamma\beta'_i\beta'_j})$$

Taking contraction of the indices i and j ,we get spectral equations corresponding to the three-point correlation equations

$$\begin{aligned}&\frac{\partial}{\partial t}\left(\overline{\phi_l\beta'_i\beta''_j}\right)+\frac{\nu}{p_M}[(1+p_M)(k^2+k'^2)+2p_M kk'+R]\left(\overline{\phi_l\beta'_i\beta''_j}\right)=\\&i(k_k+k'_k)(\overline{\phi_l\phi_k\beta'_i\beta'_j})-i(k_k+k'_k)(\overline{\beta_l\beta_k\beta'_i\beta'_j})-i(k_k+k'_k)(\overline{\phi_l\phi'_k\beta'_i\beta'_j})\\&+i(k_k+k'_k)(\overline{\phi_l\phi'_i\beta'_k\beta'_j})+i(k_l+k'_l)(\overline{\gamma\beta'_i\beta'_j})\end{aligned} \tag{16}$$

and

$$-(\overline{\gamma\beta'_i\beta''_j})=\frac{(K_lK_k+K'_lK_k+K_lk'_k+K'_lK'_k)}{(K_l^2+K'^2_l+2K_lK'_l)}\ (\overline{\phi_l\phi_k\beta'_i\beta''_i}-\overline{\beta_l\beta_k\beta'_i\beta''_j}) \tag{17}$$

Notes

IV. Mathematical Formulation

To find the four point correlation equation, following Deissler's [17] we take the momentum equation of dusty fluid MHD turbulence in a first order chemical reaction at the point p and the induction equation of magnetic field fluctuation at p', p'' and p''' as

$$\frac{\partial u_l}{\partial t}+u_k\frac{\partial u_l}{\partial x_k}-h_k\frac{\partial h_l}{\partial x_k}=-\frac{\partial w}{\partial x_l}+\nu\frac{\partial^2 u_l}{\partial x_k\partial x_k}-Ru_l+f(u_l-v_l) \tag{18}$$

$$\frac{\partial h_i'}{\partial t}+u_k'\frac{\partial h_i'}{\partial x_k'}-h_k'\frac{\partial u_i'}{\partial x_k'}=\frac{\nu}{p_M}\frac{\partial^2 h_i'}{\partial x_k'\partial x_k'} \tag{19}$$

$$\frac{\partial h_j''}{\partial t}+u''\frac{\partial h_j''}{\partial x_k''}-h''\frac{\partial u_j''}{\partial x_k''}{}_k=\frac{\nu}{p_M}\frac{\partial^2 h_j''}{\partial x_k''\partial x_k''} \tag{20}$$

$$\frac{\partial h_m'''}{\partial t}+u_k'''\frac{\partial h_m'''}{\partial x_k'''}-h_k'''\frac{\partial u_m'''}{\partial x_k'''}=\frac{\nu}{p_M}\frac{\partial^2 h_m'''}{\partial x_k'''} \tag{21}$$

where $w=\frac{p}{\rho}+\frac{1}{2}\langle h^2\rangle$ is the total MHD pressure, $p(\hat{x},t)$ is the hydrodynamic pressure, ρ is the fluid density, $P_M=\frac{\nu}{\lambda}$ is the Magnetic Prandtl number, Ω_s is the angular velocity components, $m_i=\frac{4}{3}\pi R^3{}_i\rho_i$ is the mass of a single spherical dust particle of radius R_i and ρ_i constant density of the material in dust particles, R is the first order chemical reaction $f=\frac{KN}{\rho}$, is the dimensions of frequency, K is the Stock's drug resistance, N is the constant number density of dust particle. ν, is the kinematics viscosity, λ is the magnetic diffusivity, $h_i(x,t)$ is the magnetic field fluctuation, $u_k(x,t)$ is the turbulent velocity, v_l dust velocity component, t is the time, x_k is the space co-ordinate and repeated subscripts are summed from 1 to 3.

Multiplying equation (18) by $h_i'h_j''h_m'''$ (19) by $u_l h_j'' h_m'''$ (20) by $u_l h_i' h_m'''$ (21) by $u_l h_i' h_j''$ and adding the four equations, we than taking the angular bracket $(\overline{\ldots\ldots})$ or $\langle\ldots\ldots\ldots\rangle$, we get

$$\begin{aligned}
&\frac{\partial}{\partial t}(\overline{u_l h_i' h_j'' h_m'''})+\frac{\partial}{\partial x_k}(\overline{u_l u_k h_i' h_j'' h_m'''})-\frac{\partial}{\partial x_k}(\overline{h_k h_l h_i' h_j'' h_m'''})+\\
&\frac{\partial}{\partial x_k'}(\overline{u_l u_k h_i' h_j'' h_m'''})-\frac{\partial}{\partial x_k'}(\overline{u_l u_i' h_k' h_j'' h_m'''})+\frac{\partial}{\partial x_k''}(\overline{u_l u_k'' h_i' h_j'' h_m'''})-\\
&\frac{\partial}{\partial x_k''}(\overline{u_l u_j'' h_i' h_k'' h_m'''})+\frac{\partial}{\partial x_k'''}(\overline{u_l u_k''' h_i' h_j'' h_m'''})-\frac{\partial}{\partial x_k'''}(\overline{u_l u_j''' h_i' h_j'' h_m'''})=\\
&-\frac{\partial}{\partial x_l}(\overline{w h_i' h_j'' h_m'''})+\frac{\partial^2}{\partial x_k \partial x_k}(\overline{u_l h_i' h_j'' h_m'''})+\frac{\nu}{p_M}[\frac{\partial^2}{\partial x_k' \partial x_k'}(\overline{u_l h_i' h_j'' h_m'''})+\\
&\frac{\partial^2}{\partial x_k'' \partial x_k''}(\overline{u_l h_i' h_j'' h_m'''})+\frac{\partial^2}{\partial x_k''' \partial x_k'''}(\overline{u_l h_i' h_j'' h_m'''})]-R\left[\overline{u_l h_i' h_j'' h_m''}\right]\\
&+\mathrm{f}\left[\left(\overline{u_l h_i' h_j'' h_m'''}\right)-\left(\overline{v_l h_i' h_j'' h_m''}\right)\right]
\end{aligned} \tag{22}$$

Ref

17. M. A. K. Azad, M. A. Aziz and M. S. Alam Sarker, Statistical theory of certain distribution functions in MHD turbulent flow for velocity and concentration undergoing a first order reaction in a rotating system, Bangladesh Journal of Scientific & Industrial Research 46(1)59-68-68, 2011.

Using the transformations,

$$\frac{\partial}{\partial x_k''}=\frac{\partial}{\partial r_k'},\ \frac{\partial}{\partial x_k'}=\frac{\partial}{\partial r_k'},\ \frac{\partial}{\partial x_k}=-(\frac{\partial}{\partial r_k'}+\frac{\partial}{\partial r_k'}+\frac{\partial}{\partial r_k''})$$

and Fourier transforms

$$\langle u_l h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{23}$$

$$\langle u_l u_k' h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\phi_k'(\hat k)\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{24}$$

$$\langle u_l u_i' h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\phi_i'(\hat k)\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{25}$$

$$\langle u_l u_k'' h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\phi_k''(\hat k')\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{26}$$

$$\langle u_l u_j'' h_i'(\hat r)h_k''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\phi_j''(\hat k')\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{27}$$

$$\langle u_l u_k h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\phi_k\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{28}$$

$$\langle u_l u_i'' h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\phi_l\phi_i''(\hat k')\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{29}$$

$$\langle w h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\delta\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{30}$$

$$\langle v_l h_i'(\hat r)h_j''(\hat r')h_m'''(\hat r'')\rangle=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\langle\eta_l\gamma_i'(\hat k)\gamma_j''(\hat k')\gamma_m'''(\hat k'')\rangle\exp[i(\hat k.\hat r+\hat k'.\hat r'+\hat k''.\hat r'')d\hat k d\hat k' d\hat k'', \tag{31}$$

with the fact

$$\langle u_l u_k''' h_i' h_j'' h_m'''\rangle=\langle u_l u_k' h_i' h_j'' h_m'''\rangle,$$
$$\langle u_l u_k''' h_i' h_j'' h_m'''\rangle=\langle u_l u_k' h_i'' h_j'' h_m'''\rangle,$$
$$\langle u_l u_m''' h_i' h_j'' h_m'''\rangle=\langle u_l u_i' h_i' h_k' h_j'' h_m'''\rangle,$$
$$\langle u_l u_j'' h_i' h_k'' h_m'''\rangle=\langle u_l u_i' h_i' h_k' h_j'' h_m'''\rangle,$$

and by taking contraction of the indices i and j, i and m, we obtained four-point correlation equation as

$$\frac{\partial}{\partial t}\left(\overline{\phi_l\gamma_i'\gamma_i''\gamma_m'''}\right)+\frac{\nu}{p_M}[(1+p_M)(k^2+k'^2+k''^2)+2p_M kk'$$
$$+2p_M kk''+2p_M kk'''](\overline{\phi_l\gamma_i'\gamma_i''\gamma_m'''})+(R-f)(\overline{\phi_l\gamma_i'\gamma_i''\gamma_m'''})$$
$$+f(\overline{\eta_l\gamma_i'\gamma_i''\gamma_m'''})=i(k_k+k_k'+k_k'')(\overline{\phi_l\phi_k\gamma_i'\gamma_i''\gamma_m'''})$$
$$-i(k_k+k_k'+k_k'')(\overline{\gamma_l\gamma_k\gamma_i'\gamma_i''\gamma_m'''})-i(k_k+k_k'+k_k'')(\overline{\phi_l\phi_k'\gamma_i'\gamma_i''\gamma_m'''})$$

Notes

$$+i(k_k+k'_k+k''_k)(\overline{\phi_l\phi'_i\gamma'_k\gamma'_i\gamma'''_m})+i(k_k+k'_k+k''_k)(\overline{\delta\gamma'_k\gamma'_i\gamma'''_m}). \quad (32)$$

If we take the derivative with respect to x_l of equation (18) and multiplying by $h'_i h''_j h'''_m$, using time averages and writing the equation in terms of the independent variables $\hat{r},\hat{r}',\hat{r}''$, we have

Notes

$$-(\overline{\delta\gamma'_i\gamma''_j\gamma'''_m})=$$

$$\frac{(k_lk_k+k_lk'_k+k_lk''_k+k'_lk_k+k'_lk'_k+k'_lk''_k+k''_lk_k+k''_lk_k+k''_lk'_k+k''_lk''_k)}{k_lk_l+k'_lk'_l+k''_lk''_l+2k_lk'_l+2k'_lk''_l+2k_lk''_l}$$

$$\times(\overline{\phi_l\phi_k\gamma'_i\gamma''_j\gamma'''_m}-\overline{\gamma_l\gamma_k\gamma'_i\gamma''_j\gamma'''_m}). \quad (33)$$

Equation (32) and (33) are the spectral equation corresponding to the four-point correlation equation.

A relation between $\phi_l\phi'_k\beta'_i\beta''_j and\ \phi_l\gamma'_i\gamma''_j\gamma'''_m$ can be obtained by letting $\hat{r}''=0$ in equation (23) and comparing the result with equation (11), we get

$$\left\langle \phi_l\phi'_k(\hat{k})\beta'_i(\hat{k})\beta''_j(\hat{k}')\right\rangle=\int_{-\infty}^{\infty}\left\langle \phi_l\gamma'_i(\hat{k})\gamma''_j(\hat{k}')\gamma'''_m(\hat{k}'')\right\rangle d\hat{k}'' \quad (34)$$

The relation between $\alpha_i\varphi_k\varphi'_j(\hat{k})$ and $\varphi_l\beta'_i\beta''_j$ is obtained by letting $\hat{r}'=0$ in equation (17) and comparing the result with equation (5), then

$$\left\langle \alpha_i\varphi_k\varphi'_i(\hat{k})\right\rangle=\int_{-\infty}^{\infty}\left\langle \phi_i\beta'_i(\hat{k})\beta''_i(\hat{k}')\right\rangle d\hat{k}' \quad (35)$$

V. Solution Neglecting Quintuple Correlations

Using $f\left(\overline{\eta_l\gamma'_i\gamma''_i\gamma'''_m}\right)=L\left(\overline{\phi_l\gamma'_i\gamma''_i\gamma'''_m}\right)$, 1-$L$=s, and neglecting all the terms on the right side of equation (32), then integrating between t_1 and t, we get

$$\left\langle \phi_l\gamma'_i\gamma''_j\gamma'''_m\right\rangle=$$

$$\left\langle \phi_l\gamma'_i\gamma''_j\gamma'''_m\right\rangle_1\exp\{\frac{-\nu}{p_M}(1+p_M)\left(k^2+k'^2+k''^2+2kk'+2k'k''+2kk'\right)-R+fs\}(t-t_1) \quad (36)$$

For small values of k, k' and k'' $\left\langle \phi_l\gamma'_i\gamma''_j\gamma'''_m\right\rangle_1$ is the value of $\left\langle \phi_l\gamma'_i\gamma''_j\gamma'''_m\right\rangle$ at $t=t_1$. Substituting of equations (17), (33),(34) (35),(36) in equation (16) and integrating with respect to k''_1,k''_2,k''_3 and farther integrating with respect to time, and in order to simplify calculations, we will assume that $[a]_1=0$ and the integration is performed, then substituting the obtained equation in equation (4) and setting $H=2\pi k^2\varphi_i\varphi'_i$,we obtain

$$\frac{\partial H}{\partial t}+(\frac{2\nu k^2}{p_M})H=G \quad (37)$$

where,

$$G=k^2\int_{-\infty}^{\infty}2\pi.i[\left\langle k_k\phi_l\beta'_i\beta''_i(\hat{k},\hat{k}')\right\rangle-\left\langle k_k\phi_l\beta'_i\beta''_i(-\hat{k},-\hat{k}')\right\rangle]_0\cdot\exp\{-(R-fs)(t-t_o)\}$$

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$$\exp[-\frac{\nu}{p_M}(t-t_0)\{(1+p_M)(k^2+k'^2)+2p_M kk'\}]dk'$$

$$+k^2\int_{-\infty}^{\infty}\frac{2p_M.\pi^{\frac{5}{2}}}{\nu}i\left[b(\hat{k}.\hat{k}')-b(-\hat{k}.-\hat{k}')\right]_1.\exp\{-R(t-t_1)\}$$

$$.-\omega^{-1}\exp[-\omega^2\left(\frac{(1+2p_M)k^2}{(1+p_M)^2}+\frac{2P_m kk'}{1+p_M}+k'^2\right)]$$

$$+k.\exp\ [-\omega^2(\ \ (1+p_M)(k^2+k'^2)+2p_M kk']\int_0^{\frac{\omega k}{2}}\exp(x^2)dx\}dk'$$

$$+k^2\int_{-\infty}^{\infty}\frac{2p_M.\pi^{\frac{5}{2}}}{\nu}i\left[c(\hat{k}.\hat{k}')-c(-\hat{k}.-\hat{k}')\right]_1\exp\{-(R-fs)(t-t_1)\}$$

$$-\omega^{-1}\exp[-\omega^2\left(k^2+\frac{2P_m kk'}{1+p_M}+\frac{(1+2p_M)k'^2}{(1+p_M)^2}\right)]$$

$$+k'\exp[-\omega^2(\ (1+p_M)(k^2+k'^2)+2p_M kk')].\int_0^{\frac{\omega k'}{2}}\exp(x^2)dx\}dk' \qquad (38)$$

where G is the energy transfer function and H is the magnetic energy spectrum function. In order to make further calculations, an assumption must be made for the forms of the bracketed quantities with the subscripts 0 and 1 in equation (38) which depends on the initial conditions.

$$(2\pi)^2[\langle k_k\phi_l\beta_i'\beta_i''(\hat{k},\hat{k}')\rangle-\langle k_k\phi_l\beta_i'\beta_i''(-\hat{k},-\hat{k}')\rangle]_0=-\xi_0(k^2k'^4-k^4k'^2) \qquad (39)$$

where ξ_0 is a constant depending on the initial conditions for the other bracketed quantities in equation (38), we get

$$\frac{4p_M.\pi^{\frac{7}{2}}}{\nu}i\left[b(\hat{k}.\hat{k}')-b(-\hat{k}.-\hat{k}')\right]_1=\frac{4p_M.\pi^{\frac{7}{2}}}{\nu}i\left[c(\hat{k}.\hat{k}')-c(-\hat{k}.-\hat{k}')\right]_1=-2\xi_1(k^4k'^6-k^6k'^4) \qquad (40)$$

Remembering, $d\hat{k}'=2\pi\hat{k}'^2d(\cos\theta)dk'$ and $kk'=kk'\cos\theta,\theta$ is the angle between $\hat{k}$ and $\hat{k}'$ and carrying out the integration with respect to θ, we get

$$G=\int_0^{\infty}[\frac{\xi_0(k^2k'^4-k^4k'^2)kk'}{\nu(t-t_0)}\{\exp[-\frac{\nu}{p_M}(t-t_0)\{(1+p_M)(k^2+k'^2)-2p_M kk'\}]$$

$$-\exp[-\frac{\nu}{p_M}(t-t_0)\{(1+p_M)(k^2+k'^2)+2p_M kk'\}]$$

$$+\frac{\xi_1(k^4k'^6-k^6k'^4)kk'}{\nu(t-t_0)}\exp[fs(t-t_1)](\omega^{-1}\exp[-\omega^2\left(\frac{(1+2p_M)k^2}{(1+p_M)^2}-\frac{2p_M kk'}{(1+p_M)}+k'^2\right)]$$

$$-\omega^{-1}\exp[-\omega^2\left(\frac{(1+2p_M)k^2}{(1+p_M)^2}+\frac{2p_M kk'}{(1+p_M)}+k'^2\right)]$$

Notes

$$+\omega^{-1}\exp[-\omega^2\left(k^2-\frac{2p_M kk'}{(1+p_M)}+\frac{(1+2p_M)k'^2}{(1+p_M)^2}\right)]$$

$$-\omega^{-1}\exp[-\omega^2\left(k^2+\frac{2p_M kk'}{(1+p_M)}+\frac{(1+2p_M)k'^2}{(1+p_M)^2}\right)]$$

$$-\omega^{-1}\exp[-\omega^2\left(k^2+\frac{2p_M kk'}{(1+p_M)}+\frac{(1+2p_M)k'^2}{(1+p_M)^2}\right)]$$

$$+\{k\exp[-\omega^2((1+p_M)(k^2+k'^2)-2p_M kk')]$$

$$-k\exp[-\omega^2((1+p_M)(k^2+k'^2)+2p_M kk')]\}\int_0^{\frac{\omega k}{2}}\exp(x^2)dx$$

$$+\{k'\exp[-\omega^2((1+p_M)(k^2+k'^2)-2p_M kk')]$$

$$-k'\exp[-\omega^2((1+p_M)(k^2+k'^2)+2p_M kk')]\}\int_0^{\frac{\omega k'}{2}}\exp(x^2)dx)]dk' \tag{41}$$

here, $\omega=\left(\frac{\nu(t-t_1)(1+p_M)}{p_M}\right)^{\frac{1}{2}}$.

Integrating equation (41) with respect to k', we have

$$G=G_\beta+G_\gamma\exp\{-(R-fs)(t-t_1\} \tag{42}$$

where,

$$G_\beta=-\frac{\pi^{\frac{1}{2}}\xi_0 p_M{}^{\frac{5}{2}}}{\nu^{\frac{3}{2}}(t-t_0)^{\frac{3}{2}}(1+p_M)^{\frac{5}{2}}}\exp\left\{-\frac{\nu(t-t_0)(1+2p_M)k^2}{p_M(1+p_M)}\right\}$$

$$\left[\frac{15p_M k^4}{4\nu^2(t-t_0)^2(1+p_M)}+\left\{\frac{5p_M{}^2}{(1+p_M)^2\nu(t-t_0)}-\frac{3}{2\nu(t-t_0)}\right\}k^6+\frac{p_M}{1+p_M}\left\{\frac{p_M{}^2}{(1+p_M)^2}-1\right\}k^8\right]$$

and

$$G_\gamma=G_{\gamma_1}+G_{\gamma_2}+G_{\gamma_3}+G_{\gamma_4}$$

$$G_{\gamma_1}=\frac{\xi_1\sqrt{\pi}p^5{}_M}{8\nu^2(t-t_1)^2(1+p_M)^5}\exp\left(\frac{-\nu(t-t_1)(1+2p_M-p^2{}_M)}{p_M(1+p_M)}\right)k^2$$

$$[\frac{90p_M k^6}{\nu^4(t-t_1)^4(1+p_M)}+3\left\{\frac{4p_M}{\nu^2(t-t_1)^2(1+p_M)}+\frac{2p^2{}_M}{\nu^3(t-t_1)^3(1+p_M)^2}-\frac{1}{\nu^3(t-t_1)^3}\right\}k^8$$

$$+\left\{\frac{64p^2{}_M}{\nu(t-t_1)(1+p_M)^2}+\frac{10p^3{}_M}{\nu^2(t-t_1)^2(1+p_M)^3}-\frac{40}{\nu(t-t_1)}\right\}k^{10}$$

$$+8\left\{\left(\frac{p_M}{1+p_M}\right)^2-\left(\frac{p_M}{1+p_M}\right)\right\}k^{12}$$

$$G_{\gamma_2} = \frac{\xi_1 \sqrt{\pi}\, p^5{}_M (1+p_M)^4}{8\nu^2 (t-t_1)^2 (1+2p_M)^{9/2}} \exp\left(\frac{-\nu(t-t_1)(1+p_M)(1+2p_M - p^2{}_M)}{p_M(1+p_M)} \right) k^2$$

$$[\frac{90 p_M (1+p_M) k^6}{\nu^4 (t-t_1)^4 (1+2p_M)} + \left\{ \frac{120 p_M (1+p_M)}{\nu^2 (t-t_1)^2 (1+2p_M)} + \frac{2p^2{}_M (1+p_M)^2}{\nu^3 (t-t_1)^3 (1+2p_M)^2} - \frac{1}{\nu^3 (t-t_1)^3} \right\} k^8$$

$$+ \left\{ \frac{64 p^2{}_M (1+p_M)^2}{\nu(t-t_1)(1+2p_M)^2} - \frac{40}{\nu(t-t_1)} + \frac{10 p^3{}_M (1+p_M)^3}{\nu^2 (t-t_1)^2 (1+2p_M)^3} \right\} k^{10}$$

$$+ \left\{ 8p^3{}_M \left(\frac{1+p_M}{1+2p_M} \right)^3 - \left(\frac{p_M(1+p_M)}{1+2p_M} \right) \right\} k^{12}]$$

$$G_{\gamma_3} = \frac{\xi_1 \pi^{\frac{1}{2}} p^{\frac{9}{2}}{}_M}{8\nu^{\frac{3}{2}} (t-t_1)^{\frac{3}{2}} (1+p_M)^8} \exp\left(\frac{-\nu(t-t_1)(1+p_M)(1+2p_M - 2p^2{}_M)}{p_M(1+p_M)}\right) k$$

$$[\frac{90 p_M k^7}{\nu^2 (t-t_1)^2 (1+p_M)^2} + \{ \frac{120 p_M}{\nu^2 (t-t_1)^2} + \frac{60 p^2{}_M}{\nu^3 (t-t_1)^3 (1+p_M)^2} - \frac{30}{\nu^3 (t-t_1)^3} \} k^9$$

$$+ \{ \frac{64 p^2{}_M}{\nu(t-t_1)} + \frac{10 p^3{}_M}{\nu^2 (t-t_1)^2 (1+p_M)^2} - \frac{40(1+p_M)^2}{\nu(t-t_1)} \} k^{11} + \{ p^2{}_M - p_M (1+p_M)^2 \} k^{13}] \int_0^{\frac{\omega_1}{2}} \exp(y^2)\, dy$$

here, $\omega_1 = \left(\frac{\nu(t-t_1)(1+p_M)}{p_M} \right)^{\frac{1}{2}} k$

$$G_{\gamma_4} = \frac{\xi_1 \pi^{1/2} p^{15/2}{}_M}{2^8 \nu(t-t_1)(1+p_M)^{29/2}} \exp\left(\frac{-\nu(t-t_1)(1+p_M)(1+2p_M)}{p_M}\right) k^2$$

$$[\frac{7560(1+p_M)^3}{\nu^4 (t-t_1)^2 p^2{}_M} k^6 + \{ \frac{20160(1+p_M)^5}{\nu^3 (t-t_1)^3 p_M} - \frac{4233600(1+p_M)^7}{\nu^3 (t-t_1)^3 p^3{}_M} \} k^8 +$$

$$\{ \frac{12096(1+p_M)^5}{\nu^2 (t-t_1)^2} - \frac{3360(1+p_M)^7}{\nu^2 (t-t_1)^2 p^2{}_M} \} k^{10} + \{ \frac{2304(1+p_M)^5 p_M}{\nu(t-t_1)} - \frac{1344(1+p_M)^9}{p^2{}_M} \} k^{12}$$

$$\{ 128(1+p_M)^5 p^2{}_M - 128(1+p_M)^7 \} k^{14} + \ldots]$$

In equation (42), the quantity G_β represents the transfer function arising due to consideration of magnetic field at 3 and G_γ for four-point correlation equation in a chemical reaction. Integration of equation (42) over all wave numbers shows that

$$\int_0^\infty G\, d\boldsymbol{k} = 0 \tag{43}$$

Since G is a measure of transfer of energy and the numbers must be zero it satisfies the conditions of continuity and homogeneity, from (37),

$$H = \exp\left[-\frac{2\nu k^2 (t-t_0)}{p_M} \right] \int G \exp\left[-\frac{2\nu k^2 (t-t_0)}{p_M} \right] dt + J(k) \exp\left[-\frac{2\nu k^2 (t-t_0)}{p_M} \right],$$

Notes

where, $J(k)=\frac{N_0 k^2}{\pi}$ is a constant of integration and can be obtained as by Corrsin [5]. Therefore we obtain,

$$H=\frac{N_0 k^2}{\pi}\exp[\frac{-2\nu k^2(t-t_0)}{p_M}]+\exp[\frac{-2\nu k^2(t-t_0)}{p_M}]\int[G_\beta+(G_{\gamma_1}+G_{\gamma_2}+G_{\gamma_3}+G_{\gamma_4})$$

$$\exp\{-(R_s-fs)(t-t_1)\}]\exp[\frac{-2\nu k^2(t-t_0)}{p_M}]dt \tag{44}$$

From equation (42), we get

$$H=H_1+H_2\exp\{(-R+fs)(t-t_1)\} \tag{45}$$

In equation (45) H_1 and H_2 magnetic energy spectrum arising from consideration of the three and four–point correlation equations in a first order chemical reaction respectively. Equation (45) can be integrated over all wave numbers to give the total magnetic turbulent energy.

$$\frac{\langle h_i h_i'\rangle}{2}=\left[\frac{N_0 p_M^{\frac{3}{2}}\nu^{-\frac{3}{2}}(t-t_0)^{-\frac{3}{2}}}{8\sqrt{2\pi}}+\xi_0 Q\nu^{-6}(t-t_0)^{-5}\right]\exp[-R(t-t_0)]$$

$$+[\xi_1 L_1\nu^{-\frac{17}{2}}(t-t_1)^{-\frac{15}{2}}+\xi_1 L_2\nu^{-\frac{19}{2}}(t-t_1)^{-\frac{17}{2}}]\exp\{-(R-fs)(t-t_1)\} \tag{46}$$

This represents the equation of the decay of dusty fluid MHD turbulence in a first order chemical reaction for four point correlation.

$$Q=\frac{\pi.p^6 M}{(1+P_M)(1+2P_M)^{5/2}}$$

$$\left\{\frac{9}{16}+\frac{5P_M(7P_M-6)}{(1+2P_M)}-\frac{35P_M(3p^2{}_M-2p_M+3)}{8(1+2p_M)^2}+\frac{8p_M(3p^2{}_M-2p_M+3)}{3.2^6.(1+2p_M)^3}+\ldots\right\}$$

here,

$L_1=Q_2+Q_4+Q_6+Q_7, L_2=Q_1+Q_3+Q_5$ and $Q^{,s}$ values

$$Q_1=-\frac{\pi.p^6{}_M}{(1+p_M)^{5/2}(1+2p_M-p^2{}_M)^{7/2}}$$

$$[\frac{15.9}{2^6}+\frac{15.7(15-6p_M+21p^2{}_M)}{2^{10}(1+2p_M-p^2{}_M)}+\frac{15.7.3(15-6p_M+36p^2{}_M-6p^3{}_M+61p^4{}_M)}{2^{11}(1+2p_M-p^2{}_M)^2}+$$

$$\left(\frac{11.9.7(1+p^2{}_M)(75-30p_M+180p^2{}_M-30p^3{}_M+305p^4{}_M)}{2^{13}(1+2p_M-p^2{}_M)^3}\right)+$$

$$\left(\frac{13.11.9.7(1+p^2{}_M)^2(75-3p_M+90p^2{}_M-30p^3{}_M+15p^4{}_M)}{2^{14}(1+2p_M-p^2{}_M)^4}\right)-\ldots\ldots\ldots\ldots]$$

$$Q_2=-\frac{\pi.p^{21/2}{}_M}{(1+p_M)^{3/2}(1+2p_M-p^2{}_M)^{9/2}}$$

Ref

5. S. Corrsin, On the spectrum of isotropic temperature fluctuations in isotropic turbulence. J. Appl. Phys. **22**, 469-473 (1951). http://dx.doi.org/10.1063/1.1699986

$$[\frac{15.7}{2^6}+\frac{15.9.7(14p^2{}_M-18-40p_M)}{2^9(1+2p_M-p^2{}_M)}+\frac{15.11.9.7(14p^4{}_M-56p^3{}_M-12p^2{}_M-40p_M-18)}{2^{10}(1+2p_M-p^2{}_M)^2}-\quad\ldots]$$

$$Q_3=-\frac{\pi.p^{19/2}{}_M(1+p_M)^{1/2}}{(1+2p_M)^2(1+2p_M-p^2{}_M)^{7/2}}\quad.$$

$$[\frac{9.15}{2^6}+\frac{15.7(17+32p_M-2p^2{}_M+4p^3{}_M+20p^4{}_M)}{2^{10}(1+p_M)^2(1+2p_M-p^2{}_M)}$$

$$+\frac{9.7.5(17+49p_M+13p^2{}_M-13p^3{}_M+98p^4{}_M+134p^5{}_M+104p^6{}_M+60p^7{}_M)}{2^{11}(1+p_M)^3(1+2p_M-p^2{}_M)^2}$$

$$+(\frac{11.9.7.5(1+p_M-p^2{}_M+p^3{}_M)(17+49p_M+13p^2{}_M-13p^3{}_M+98p^4{}_M+134p^5{}_M+104p^6{}_M+60p^7{}_M)}{2^{13}(1+p_M)^4(1+2p_M-p^2{}_M)^3}$$

$$+(\frac{13.11.9.7.5(1+p_M-p^2{}_M+p^3{}_M)^2(17+49p_M+13p^2{}_M-13p^3{}_M+98p^4{}_M+134p^5{}_M+104p^6{}_M+60p^7{}_M)}{2^{14}(1+p_M)^5(1+2p_M-p^2{}_M)^4})-\ldots]$$

$$Q_4=-\frac{\pi.p^{21/2}{}_M}{(1+p_M)^{1/2}(1+2p_M)(1+2p_M-p^2{}_M)^{9/2}}\quad[\frac{25.7.3}{2^5}+$$

$$\frac{15.9.7(-40p_M-48p^2{}_M+64p^3{}_M+52p^4{}_M)}{2^9(1+p_M)^2(1+2p_M-p^2{}_M)}+$$

$$\frac{15.11.9.7(-40p_M-89p^2{}_M+51p^3{}_M+124p^4{}_M-40p^5{}_M+36p^6{}_M+60p^7{}_M)}{2^{10}(1+p_M)^3(1+2p_M-p^2{}_M)^2}-\ldots..]$$

$$Q_5=-\frac{\pi.p^{19/2}{}_M}{(1+p_M)^{19/2}(1+2p_M)^{9/2}}$$

$$\left\{\begin{array}{l}\frac{45.7.5.3}{2^{10}}+\frac{9.7.5.3(20p^2{}_M-70p_M-5)}{2^{11}(1+2p_M)}+\frac{11.9.7.5.3(20p^4{}_M-40p^3{}_M+160p^2{}_M-60p_m-5)}{2^{13}(1+2p_M)^2}+\\ \frac{13.11.9.7.5.3(1-2p_M)(20p^4{}_M-40p^3{}_M+160p^2{}_M-60p_M-5)}{2^{14}.(1+2p_M)^3}-\ldots\ldots\ldots\ldots\end{array}\right\}$$

$$Q_6=-\frac{\pi.p^{21/2}{}_M}{(1+p_M)^{15/2}(1+2p_M)^{11/2}}\left\{\frac{15.9.7.5.3}{2^8}+\frac{11.9.7.5.3(24p^2{}_M-200p_M+20)}{2^{11}(1+2p_M)}-\ldots\ldots\ldots\ldots\ldots\ldots\right\}$$

$$Q_7=-\frac{\pi.p^9{}_M}{(1+p_M)^{23/2}(1+2p_M)^{7/2}}$$

$$[\{\frac{9.7.5.3}{2^{11}}-\frac{7.5.3(4231710+16938180p_M+25381440p^2{}_M+1689480p^3{}_M+4213440p^4{}_M}{2^{13}(1+2p_M)}\}$$

$$(9.7.5.3(2115855+4237380p_M-4245780p^2{}_M-16927680p^3{}_M-14783328p^4{}_M$$

$$-\{\frac{-4218816p^5{}_M-4368p^6{}_M)}{2^{14}(1+2p_M)^2}\}\ldots]$$

Equation (46) can be written as

$$\frac{\langle h^2\rangle}{2}=\left(AT_0^{\frac{-3}{2}}+BT_0^{-5}\right)\exp(-RT_0)+\left(CT^{\frac{-15}{2}}+DT^{\frac{-17}{2}}\right)\exp\{(-R+M)T\}.\qquad(47)$$

Notes

Where, $T_0 = (t - t_0)$ and $T = (t - t_1)$

This is the equation of 4-point correlations of dusty fluid MHD turbulence in a first order chemical reaction.

VI. Results and Discussion

The first term of right hand side of equation (47) corresponds to the energy of magnetic field fluctuation of two-point correlation; the second term represents magnetic energy for the three-point correlation; the third and fourth term represents magnetic energy for four-point correlation. For large times, the second term in the equation becomes negligible, leaving the -3/2 power decay law for the ending phase.

If Chemical reaction and dust particles are absent then equation (47) is of the form

$$\frac{\langle h^2 \rangle}{2} = AT_0^{\frac{-3}{2}} + BT_0^{-5} + CT^{\frac{-15}{2}} + DT^{\frac{-17}{2}}. \tag{48}$$

this is the energy decay of MHD turbulence for four-point correlation. If $\xi_1 = 0$ then the equation (47) becomes

$$\frac{\langle h^2 \rangle}{2} = (AT_0^{\frac{-3}{2}} + BT_0^{-5}) \exp(-RT_0) \tag{49}$$

This was obtained earlier by Islam and Sarker [18] for 3-point correlation.

This study shows that the terms associated with the higher-order correlation's die out faster than those associated with the lower order ones. Here three and four-point correlations between fluctuating quantities have been considered and the quintuple correlations are neglected in comparison to the third and fourth order correlations. If the quadruple and quintuple correlations were not neglected, equation (46) contains more terms in negative higher power of $(t - t_1)$ and $(t - t_0)$ would be added to equation (47). In the Figures *h1, h2, h3, h4* and *h5* represents the energy decay curves in a first order chemical reaction of equation (47) at $t_0 = t_1 = 0.5$, 1, 1.5, 2, and 2.5 respectively.

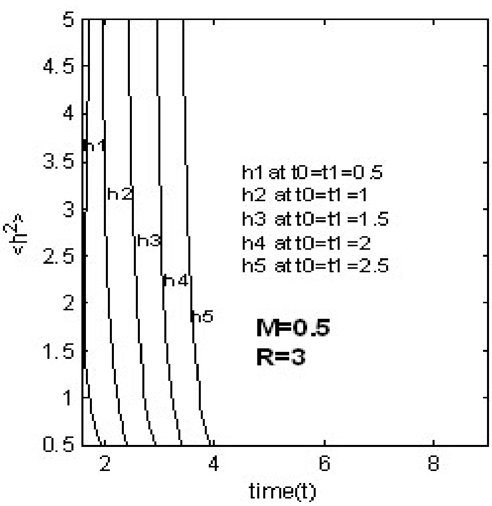
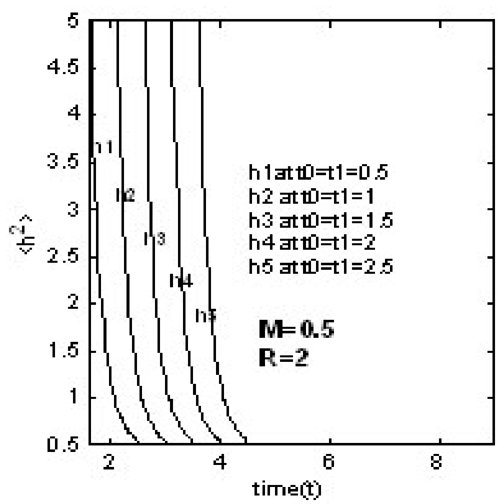


Figure 1 : Decomposing curves for *M*=0.5, *R*=0.50.



Figuyre 2 : Energy decay curves of equation (47) if *M*=0.5, *R*=2.

Ref

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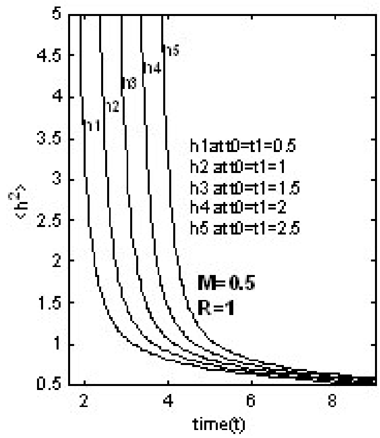

Figure 3 : Decomposing curves of equation M=0.5, R=1

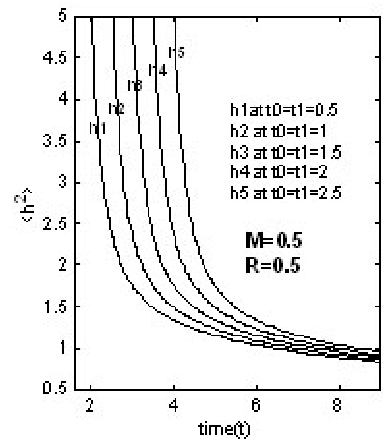

Figure 4: Energy decay curves of equation. (47) if M=0.5, R=0.5

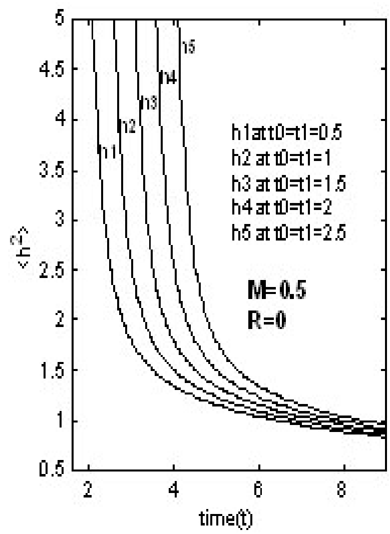

Figure 5 : Decomposing curves of equation (48) if M=0.5, R=0

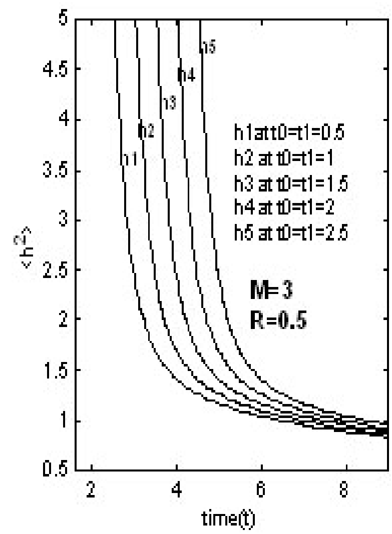

Figure 6 : Energy decay curves of equation (47) if M=3, R=0.5

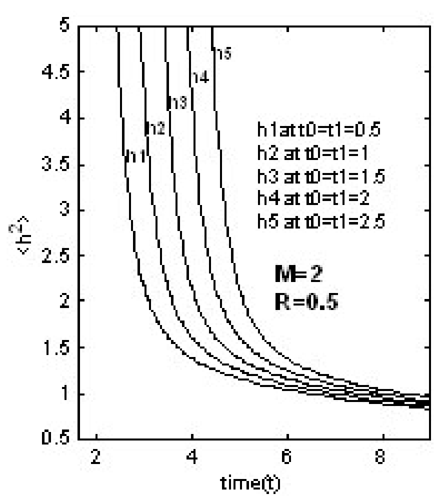

Figure 7 : Energy decay curves of equation (47) if M=2, R=0.5

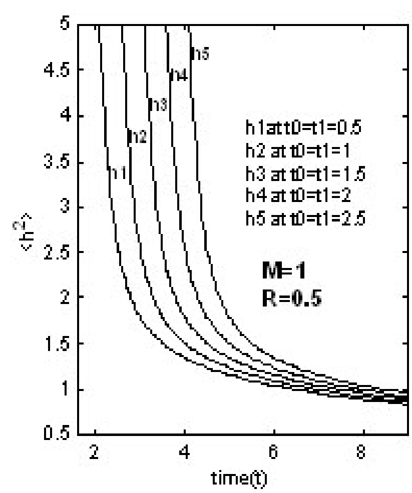

Figure 8 : Decay curves of equation (47) if M=1, R=0.5

Notes

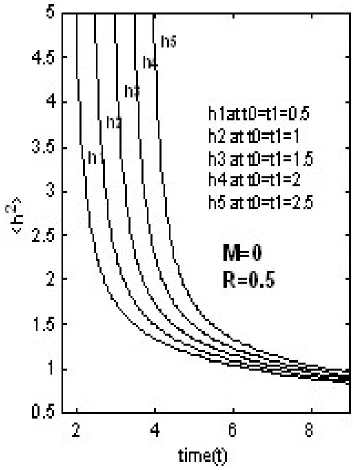

Figure 9 : Decomposing curves of equation (47) if M=0, R=0.5

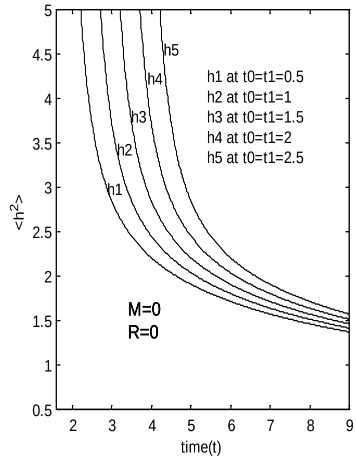

Figure 10 : Decay curves of equation (47) if M=0, R=0

In the Figures *h1, h2, h3, h4* and *h5* represents the energy decay curves in a first order chemical reaction of equation (47) at $t_0 = t_1$ =0.5, 1, 1.5, 2, and 2.5 respectively. From the Figures (1-5) we observed that if M=0.5 energy decay increases for the decreases of the values R and maximum if the chemical reaction is absent. If M=3, 2, 1, 0 then the decay of energy decreases slowly at the point where R=0.5 that are indicated in the Figures (6-9). From Figure: 10 we see that energy decay very rapidly in the clean fluid.

VII. Conclusion

We conclude that if the concentration selected in the chemical reactant of dusty fluid MHD turbulent flow of the first order at four point correlations, then the result is that the decaying of the concentration fluctuation is much more slow and the slower rate of decay is governed by $\exp[-(R-M)T]$. In the case of clean combination, the decay of concentration fluctuation is much more rapid and the faster rate of decay is due to absent of chemical reaction and dust particles.

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