CORPUS PUBLISHERS

Journal of Mineral and Material Science (JMMS)

ISSN: 2833-3616

Volume 7 Issue 2, 2026

Article Information

Received date : April 27, 2026

Published date: May 08, 2026

*Corresponding author

I A Filimonov, Merzhanov Institute of Structural Macrokinetics and Materials Science Russian Academy of Sciences (ISMAN), Academician Osipyan Str. 8, Chernogolovka, Moscow Region, 142432, Russia

DOI: 10.54026/JMMS/1136

Opinion Article

To Vortex Generation: History, Equations Conditions. Media

Filimonov IA*

Merzhanov Institute of Structural Macrokinetics and Materials Science Russian Academy of Sciences (ISMAN), Academician Osipyan Str 8, Chernogolovka, Moscow Region, 142432, Russia

Opinion

Time passes, too much and many have been already forgotten. But there are persons whose contribution into sciences is great and remains objectively indisputable or significant for ages, and we have to remember them for sure. A classic example in this regard is Albert Einstein (AE), whose name everyone knows from children up to deep old people, and from residents of the most remote and small villages or towns up to residents of the nearest central and large megacities. In the essay presented I'm going to write about one of these people: about A.A. Friedmann (see the sketch on him and his short biography below). Unfortunately, even the results and achievements of such outstanding and eminent people like A.A. Friedmann (AAF) are not safe completely now and there are still cases of unjustified partial forgetfulness and even complete oblivion related with them. For example, in the World well-known textbook [1] the equation of vorticity has been considered with no reference to him. (see eq.1 below which is, in fact, the Friedmann equation (with the accuracy of designations)

AAF has formulated and analyzed the vortex equation 20 years earlier than the German oceanographer Ertel (see the ref in [1]). Moreover, he considered the case of a compressible liquid, thereby ensuring that his conclusions were applicable to air conditions in the Earth's atmosphere, and his vortex model was not suitable only to conditions of ocean currents as is in the case of Ertel. AAF has also found that the incompressibility condition (the case of Ertel) is violated in the air atmosphere, and therefore the AAF results are more advanced and practically applicable in meteorology, and not in oceanology only, as is in case of Ertel. Thus, AAF was the first certainly who has formulated this equation, analyzed and explained the action of it in the frames of dynamic meteorology. The analysis provided and conclusions obtained by him in relation with the origin of vorticity, as well as analysis of the causes of vortices and conclusions concerning the conditions necessary for formation of cyclones and anticyclones in the Earth's atmosphere, carried out and obtained by AAF, with no doubts, are still relevant. As the example of the AAF conclusions highly valuable in current combustion theory one can recall his conclusion [2] about non-collinearity of the vectors: the reacting gas pressure gradient (∇P) and the gas density ($\nabla \rho$) as the conditions necessary for a vorticity origin in the Earth atmosphere (and in reacting gas or gas

+solid mixture also as a consequence). This significant condition is not trivial at all, since in accordance to the equation of state of an ideal gas: $P = \frac{m}{\mu}\rho RT$(2), and without changing in the gas moles number: i.e., at.

$v = \frac{m}{\mu} = const$, the gradients have to be certainly collinear with no vorticity as a consequence of eq.1 (see eq.1). A vorticity may be developed in a non-isentropic process only (that is similar to chemical reactions) and there is only the information about non-isoentropicity it in [1]. As concerns the vorticity equation, authors [1] have simplified the analysis of it and have not included in [1] the necessary conditions for a vorticity origin [3]. This question as well as the equation of Friedmann and the laws of conservation related with it have also been discussed in [4].

Let's remember the main points of [2] and main author's contributions or concepts:

a. In Vortex Dynamics and Circulation: AAF has extended Helmholtz's vortex theorems to compressible fluids, creating a framework for understanding how vortex filaments move, bend, and intensify in a gaseous, stratified environment, which is fundamental to studying cyclones and anticyclones.
b. The theoretical framework of AAF has showed that as pressure (P) decreases (such as in a low-pressure system), the angular velocity of the rotational motion of air increases. Conversely, if the pressure increases, the angular velocity of rotation tends to decrease.
c. In Compressibility of Large-Scale Motions: AAF has recognized that for large-scale atmospheric motions (deep, vertical movements), incompressibility assumptions fail. Unlike water, air density changes with both altitude and time. His theory helped account for density (ρ) changes in dynamic equations.
d. In Compressible Fluid Dynamics: Unlike earlier approaches that often treated air as an incompressible fluid, the theory of AAF has properly accounted for the changes in air density (ρ)
e. In Vortex Motion: The AAF theory specifically addresses the vortex motion (circulation) of air in the atmosphere, linking the angular velocity of air motion with pressure differences (high and low-pressure zones).
f. "Funnel" Effect: The work describes that as air pressure decreases (e.g., in a cyclonic system), the angular velocity of rotation increases, creating a "funnel" or vortical motion, often referred to as a "lifting force" or the mechanism behind the rotation of cyclones.

Prof. Alexandr Alexandrovich Friedmann (also spelled as Friedman) (1888-1925) is an outstanding Russian and Soviet mathematician, hydromechanic and meteorologist (he has developed the dynamic meteorology in Russia as a continuation of the beginnings and scraps of ideas of the Norwegian Bjerknes published [3] on 1904 in Germany). A.A. Friedman has born in1888 in Saint-Petersbourg in the family of two students. His father was a student of St. Petersburg Conservatory and a composer in future: senior A.A Friedman (1866-1909), while his mother was studying to be a ballet dancer. His grandfather was an organist (played on the organ) and conductor at the Imperial Mariinsky Theater.

He is a renowned mechanic for his time. His ideas in physics and, in particular, in gas dynamics, as well as in cosmology were definitely ahead of his time. For example, his non-steady model of the Universe was a reasonable and valuable alternative to the AE steady state model of Universe. While AE did not have enough time to admit the AAF model during the AAF lifetime, he has got acquainted with the AAF arguments (they met for this reason) and agreed with their possible validity (which should have been proved those days). AE has not initially recognized the AAF model (AAF has met with AE in reality and in connection with this meeting there is a joint photo of them both in the archive of P. Ehrenfest) The AAF model of Universe has been finally confirmed just four years later of the AAF death by the Hubble observational data of redshift in the spectra of distant galaxies in 1929 and by the Hubble space telescope data (Hubble tension) in our days (1990-2026) From 1913 AAF was working at the Pavlovsk (suburb of St. Petersburg) Aerologic Laboratory for a long time and ultimately, AAF was appointed as a director of the State geophysical observatory in 1925. The Friedmann equation may be written (for simplicity) as follows [1]:

$$\frac{\partial \vec{\omega}}{\partial t} = rot[\vec{v} \cdot \vec{\omega}] + \frac{1}{\rho^2}[\nabla\rho \cdot \nabla P] \quad (1)$$

Were $\vec{\omega}$` is vorticity, $v$` is the liquid (air) linear velocity, ρ is the air density, P is the air pressure. Unfortunately, in our time, the outstanding scientists and leaders of the combustion community are seeking only to simplify their synthesis models by combustion [5,6]. Not more. Therefore, they use the equations of laminar combustion equations only and prefer quasiisobaric approximation in their calculations thereby denying the facts of possible vortex generation by reactions with a huge change in number of gas moles involving in the synthesis (such as in oxidation or nitridation of metals). One have to note, that cyclon-anticyclone interaction has first been predicted [7] by James Clerk Maxwell on the basis of his pure mechanistic interpretation of vortexes motion and interaction between each other of them. Eq.1 is the well-known equation of vortex generation [1]. It generalizes both the Helmholtz circulation conservation theorems and reveals the conditions for a vortex generation in compressible liquid (i.e., in the atmospheric air)

Acknowledgement

The work presented above has been done under the state assignment for ISMAN (125021201988-9).

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