ECOLOGICAL CATASTROPHE IN ARCTIC: AN ANOMALOUS GULF STREAM HEATING (TO 21°C) AND SHIFT (~200 KM) TO GREENLAND DUE TO OCEAN POLLUTION BY RAINBOW OIL FILM

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Abstract: *An anomalous water heating – up to 21 ^{0}C – and ~200 km shift of the Gulf Stream to Greenland near New England coasts were observed in summer-fall of 2011. To explain this phenomenon a new physical mechanism is proposed and discussed. It is shown that the main consequence of the Deepwater Horizon (British Petroleum – BP) disaster in the Gulf of Mexico is oil rainbow slick or film formation over huge Gulf area of a hundred thousand square kilometers which has conserved the solar energy inside water and increased its temperature.*

We have shown that inertial "sliding" of Gulf Stream to Greenland as a result of strong drop of water viscosity in the vicinity of specific temperature 19-20°C which was observed in summer-fall 2011. Actually, at this temperature a several-fold reduction in sea water shear viscosity was observed earlier in turbulent flow.

We have suggested that water viscosity drop can be caused by thermally induced conversion of H_2O para/ortho spin isomers inside a turbulent vortex which formed during eastward turn of the Gulf Stream.

Keywords*: anomalous water heating due to rainbow oil film, shift of the Gulf Stream, thermally induced water viscosity reduction,ortho-H_2O and para- H_2O spin isomers, anthropogenic effect on global climate.*

Plain Language Summary: *An anomalous water heating – up to 21°C – and ~200 km northward shift of the Gulf Stream near New England coasts were observed in summer-fall of 2011. To explain this phenomenon a new physical mechanism is proposed and discussed. It is shown that water heating is a consequence of disaster in the Gulf of Mexico and of associated oil slick,*

which has led to oil rainbow film formation over the area of a hundred thousand square kilometers.

1 INTRODUCTION

In summer of 2011 the US fishermen have observed the ocean temperature in Gulf Stream surprisingly growth to 21°C and anomalous shift (~200 km) to Greenland in traverse of New England. Later, they have informed the scientists from Woods Hole Oceanographic Institution (WHOI) on this phenomenon that was never detected in the history of observations. The WHOI specialists have systematically measured ocean parameters like temperature and salinity depth profiles along some months till the end of December [1]. This data evolution is presented in Fig.1. It was established that the Gulf Stream shifted its path northward by over 200 km [1]. Anomalous heating of the ocean upper layer (up to ~8°C warmer than mean climatological value – 13-14°C on the 50 m depth) accompanied by a salinity growth could not be explained by any mechanisms known so far.

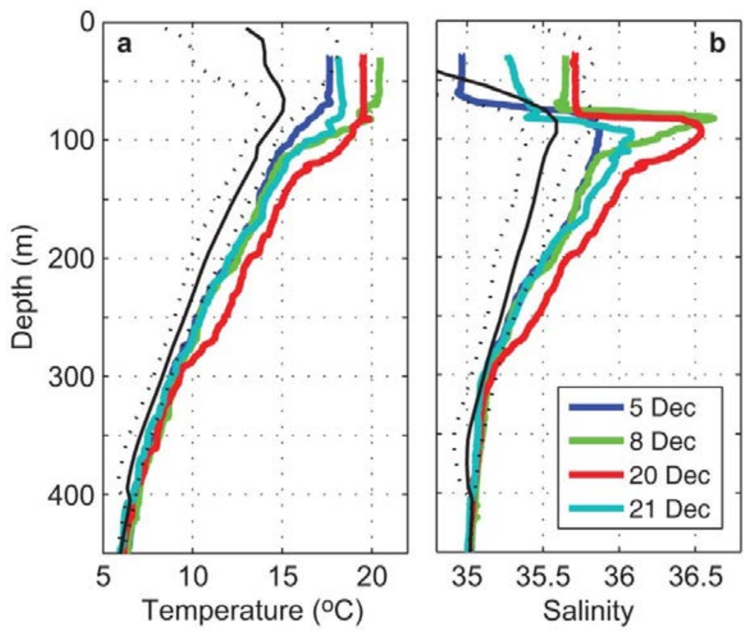

Fig. 1: Sea water temperature (a) and salinity (b) depth profiles measured near New England coasts (Reproduced from [1]). Black thin lines stand for mean climatological profiles and dotted lines represent standard deviation.

What could be the reason for the anomalous increase in temperature and, simultaneously, salinity of the Gulf Stream upper layer? Suggestions made in the work [1] and arguing that water warming could be due to warm tropical showers contradict the concurrent growth of salinity in the near-surface layer (Fig. 1) and stimulate the search for another physical mechanism [2] standing behind the ocean warming. For further examination of this phenomenon we will discuss the results of experimental studies on laser remote sensing of the rainbow oil film on water surface. The experiments were performed using a lidar based on a pulsed diode laser with an extremely low (comparable to solar) level of radiation with respect to energy density [3]. We have used the data on *temperature induced water shear viscosity reduction* [4] and quantum differences between ortho-/para-H2O spin isomers [5,6] which correlates with two-state water model [7].

2 MATERIALS AND METHODS USED FOR INVESTIGATIONS

2.1 Lidar method for filed measurements of rainbow oil film

Figure 2 schematically shows shipborne lidar system used for oil slick sensing. In our lidar we have used a pulsed diode laser as an excitation source with an extremely low energy density (comparable to solar radiation level) without disturbing the oil slick during monitoring. The lidar beam was directed to oil slick (Figure 2, track II) and clean water surface (Figure 2, track I) at an angle about 30°.

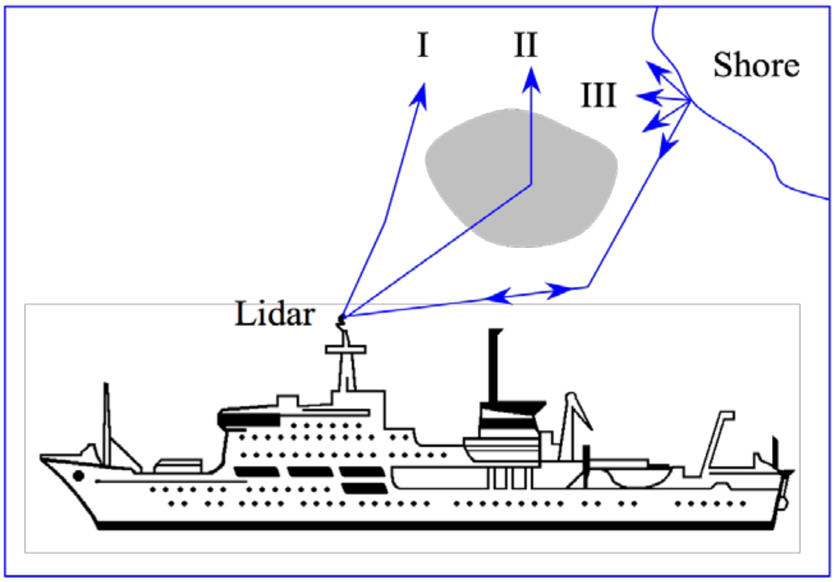

Fig. 2: Shipborne lidar sensing scheme. Tracks I-III correspond to laser beam pointed at clean water surface (I), oil silk (II) and shore objects (III).

Oil slick monitoring by this lidar showed an increase in the backscattering signal by a factor of 10 in comparison with a clean water surface. It should be mentioned that the presence of the oil slick has had a “smoothing-out” effect on the water surface, which can decrease the backscattering lidar return. In contrast, we have observed an increase.

Figure 3 shows the lidar sensing signals of oil slick (filled column) and water surface (hatched one), respectively. Intriguing that the oil slick backscattered lidar return is significantly stronger than one from water surface because, as it is well known, oil slick smoothens capillary waves on the surface.

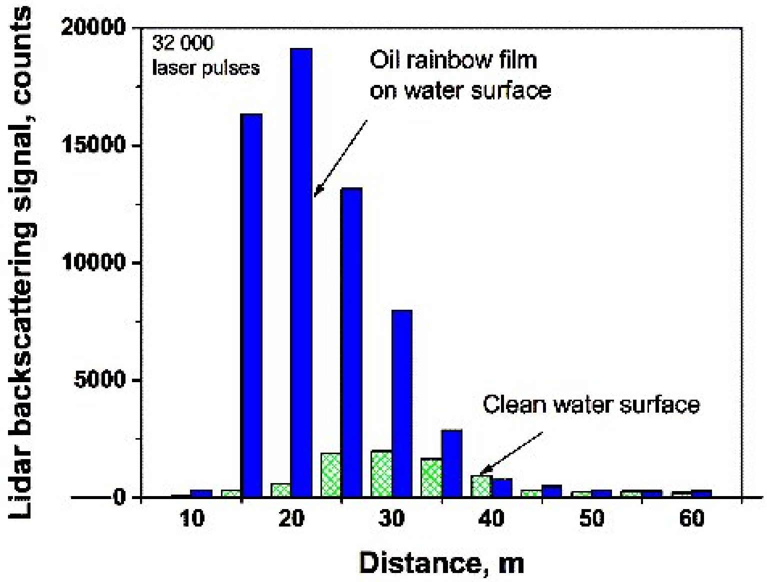

Fig. 3: Lidar backscattering signal from clean water surface (hatched columns) and oil rainbow film (filled ones).

One of the factors responsible for increasing the backscattering lidar return may be the process of H-bonded water clusters reconstruction in the subsurface layer in the vicinity of the oil slick layer. Reconstruction of the subsurface layer in water was observed earlier [8], when the polystyrene micro-balls were repulsed from the interface border into the water volume up to several microns thickness depth. So we have supposed that the oil slick can induce ice-like structure formation [8] in subsurface water layer. Further, the backscattering lidar return increased due to laser pulses interaction with this structured layer.

Fig. 4: A picture of an oil spill in Mexican Gulf, view from a helicopter. Photo from http://spill451.rssing.com/chan-5573071/all_p3.html.

It is known that clean sea water under calm conditions "transports" about 10% of solar energy in the visible range to over 100 m depth. Taking into account that the main part of solar radiation goes for heating of the 100-m thick water layer below the surface and only a small part (1–2%) is reflected according to Fresnel law. The structured water layer induced by oil slick on the water surface should be also kept in mind as it increases the scattering coefficient. So the subsurface layer several dozen meters of depth is heated more effectively in presence of the oil slick (Figure 1) than without one.

It should be noted that the oil slick, hydrocarbons (benzenes, kerosenes, etc.) and surface active substances (SASs) [9] also conserve the heat in water by actively blocking water evaporation. It is known (http://www.seapeace.ru/oceanology/atmosphere/31.html) that the value of water specific vaporization heat is 2450 kJ/kg. So, the water temperature is rising up when oil slick is present on water surface.

Actually [10], an oil slick on the water surface as anti-reflection film results in a growth of solar radiation transition into water and simultaneously reduces heat losses due to evaporation as in a classical greenhouse. Additionally, thick layers of oil spill (2-5 cm) also block evaporation, and at the same time effectively help to accumulate solar energy and transit it into water volume.

It is good to remember that around 200 tons of oil per day full filled the water of the Gulf of Mexico from the disaster day – on April 20, 2010. So, tens of thousands of square kilometers of Gulf of Mexico surface were covered by oil in form of "oil islands" by forming massive oil spots and rainbow film (Figure 4).

Finally, it is well known that the oil slick results in smoothing of small-scale gravity-capillary waves and roughness on the ocean surface. Figure 4 demonstrates how it worked in Gulf of Mexico after the disaster. It is physically clear that the surface smoothing immediately led to surface area decrease and, consequently, to a decrease in thermal energy up to ~20% [2, 10] due to evaporation losses.

It is clearly seen that small waves on the sea surface (at the bottom of Figure 4) are effectively smoothened by the oil film (upper part of the figure). The Gulf Stream temperature rising [1] (about 3% in comparison with the mean value in Figure 1, black thin lines) is equivalent to an additional power source comparable with dozens – or hundreds – of nuclear power plants. Remember that the solar constant is 1.3608 kW/m², which is 81.65 kJ/m² per minute. One can estimate the huge energy conserved in the Mexican Gulf by multiplying this value by time (months) and oil slick area (billions square meters).

This heat source was responsible for Gulf Stream water heating in Mexican Gulf area just after disaster, and then the one part of this additional heat energy was transported to the Arctic basin by the Gulf Stream. This undoubtedly is a catastrophe for the Arctic.

The other part of this additional heat energy was transformed into the tornadoes and typhoons energy over USA [11].

The question still remains, why the Gulf Stream shifted to the north after heating up to 21°C and then came back to the former path after water cooling back to 14-17°C [1]?

2.2 Laboratory results of water properties investigation near the specific point of 19°C

Let us now look at water rheological properties, which were studied in detail during past decades. In the physics of water [2, 5-7], the temperature around 19-20°C is known as the specific temperature point, i.e., the local extremum for water shear viscosity. Earlier [4] the measurements of turbulent vortexes relaxation time have shown that shear viscosity decreases – by a factor of 6 – in the vicinity of water specific point temperature 20°C (see Figure 5, squares, plotted using the data of work [4]).

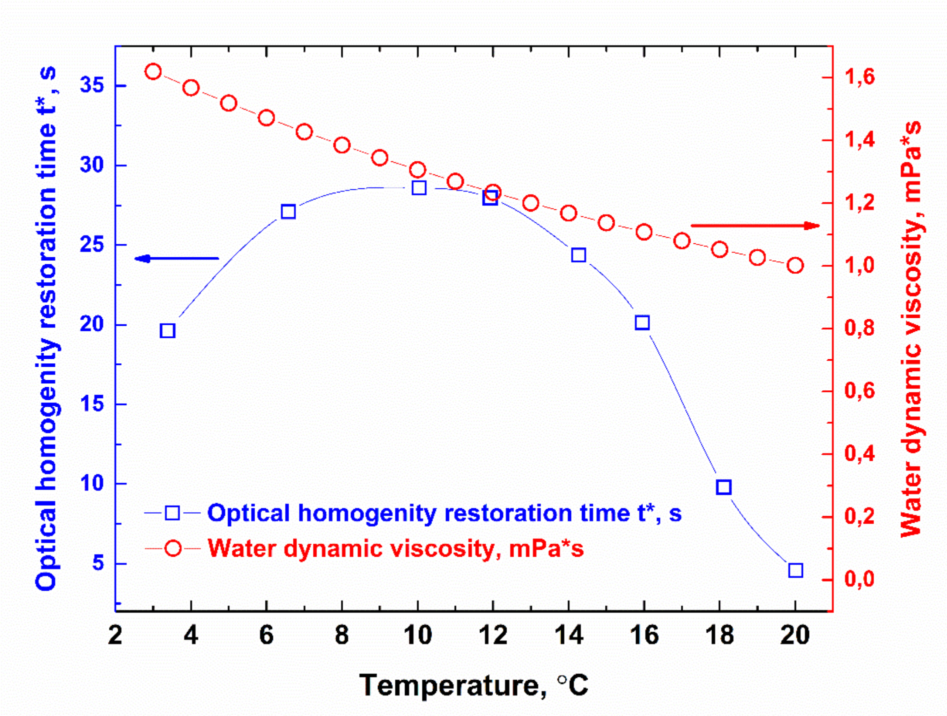

Fig. 5: Temperature dependences of saline water (0.08% NaCl) optical homogeneity restoration time after turbulent distortion (squares, left axis, reproduced from [4]) and of distilled water dynamic viscosity in laminar conditions (circles, right axis, data from [12])

Figure 5 shows that saline water shear viscosity substantially decreases (note that the time required for achieving the optical homogeneity of the turbulent vortexes is shortened in comparison with that in laminar flow – circles in Figure 5).

Thus, the Gulf Stream temperature in the vicinity of 19-21°C is **a key factor** for understanding the properties of water and its “sliding” maneuver. For the first time we pay attention to internal friction and water rheological properties during Gulf Stream turn towards the Europe. It is necessary to keep in mind that the geometry of peninsula coastline for Gulf Stream is similar to experimental configuration [4] with huge turbulent vortexes accompanied by the cavitation processes. Evidently, when sea water is heated up to 19-21°C, its viscosity drop down by factor of 6 (Figure 5, squares) due to turbulence and cavitation, rather than keeping approximately “constant” value (~20%) of laminar flow (Figure 5, circles) [12]. Therefore, such a drop in viscosity will lead to the shift in oceanic streams due to centrifugal force in areas where the Gulf Stream turns.

The physical origin of specific point temperatures, in particular 19°C (out of a few tens of others) in ice and water [5], is still unclear. We have suggested that these water anomalies and specific temperatures point existence are to be determined **by H_2O spin isomer quantum differences** [5,6]**.** Actually, rotational transitions in H_2O molecules and its spin conversion due to collisions induced by Brownian motion can change the ortho-/para ratio. It was found [5] that rotational transition energy $h\Omega_{mn}$ between the levels m and n of ortho- and para- H_2O isomers coincides with that of thermal motion kT_c in the vicinity of specific temperature point T_c:

$$kT_c = h\Omega_{mn} \quad (1)$$

where k and h are Boltzmann and Planck constants, correspondingly

Resonance collisions (1), as it was shown before [2, 5], result in rotational transitions which lead to excited (de-excited) state of ortho- or para-isomers (or both – in case of temperatures around 19°C). After transition induced by collisions to the upper (or lower) level, molecules create mixed quantum states (or quantum beats [13, 14], coupled with a close level of another H_2O isomer).

It is known [13, 14] that in mixed quantum states spin isomers undergo conversions (proton spin flip) in presence of a catalyst with a strong gradient magnetic field [5, 13–15]. In water, the most suitable catalyst is the triplet oxygen O_2 [15]. These are the reasons why the ortho-/para-conversion is more effective in turbulent water motion [2, 4], than in laminar – due to an effective H_2O molecule collisions in a gradient magnetic field in the vicinity of triplet oxygen O_2 [15].

It should be mentioned [2] that ortho-H_2O and para-H_2O spin isomers have significantly different quantum properties. Ortho-isomers have a magnetic moment and are visible in magnetic resonance imaging (MRI) and always are in rotational motion [5, 13-16]. In contrast, para-isomers have no magnetic moment (singlet states), and neither NMR nor MRI has been able to exploit the properties of the invisible singlet states [16]. So, a part of them does not rotate (proportionally to population of zero rotational level) at the room temperature in accordance to Boltzmann distribution. It is physically clear that these quantum differences are the reason for water existence as a two-liquid mixture with low and high density components [17] in dynamical equilibrium [7].

Further, the variation of an ortho-/para-isomer concentration ratio explains the ability of water molecules to form hydrogen-bonded complexes [18, 19]. Moreover, the ortho/para ratio may also be responsible for other properties of water [4, 13–17], especially in the vicinity of specific temperature points (in accordance with the equation (1)).

Actually, we have measured in our laboratory [18, 19] for the first time – as we know – that the ortho-/para- isomer concentration ratio in liquid water at room temperature is 1:1, which is non-equilibrium, i.e. it is overheated up to 270 K in terms of spin temperature [13-16]. This value is quite far from the well-known equilibrium ratio “3:1” in air [13-16]. Moreover, we have shown [19] experimentally, that the non-equilibrium state with ortho/para ratio ~1:1 increases twice – up to 2:1 – at 60°C.

3 MAIN RESULTS OF RESEARCH

A new physical mechanism of the Gulf Stream anomalous shift is proposed and discussed. We have proposed and proved that the Deepwater Horizon disaster in the Gulf of Mexico is the main reason for water heating due to oil slick in the form of rainbow film over the area of a hundred thousand square kilometers.

We have shown that the Gulf Stream shift (~200 km) to Greenland is an inertial “sliding” in the eastward turn maneuver (near Shelfbreak South of New England [1]) due to anomalous water heating to a specific temperature point (19-21°C) that occurred in the Gulf of Mexico. It was found that at this temperature a multiple-fold reduction in sea water shear viscosity takes place, which was observed earlier in turbulent flow [4].

We have suggested that water viscosity drop can be caused by thermally induced conversion of H2O para-/ortho-spin isomers inside a turbulent vortex which formed during the eastward turn of the Gulf Stream.

4 CONCLUSIONS

In the present paper we concluded that ecological catastrophe in Arctic has occurred: an anomalous Gulf Stream heating (to 21°C) and shift (~200 km) to Greenland due to ocean pollution by rainbow oil film as a sequence of Deepwater Horizon disaster in the Gulf of Mexico led to the Stream as a source of huge thermal power (~10^{15} W [20]) transportation closer to Greenland. Experts estimate [21] that about 20% of the ocean surface is now contaminated by products of the raw oil spill and by presence of oil rainbow film. So the lidar remote sensing techniques based on unmanned platforms together with satellite imaging allow us to estimate the scale of contamination by rainbow film and to make forecasts. The other key parameter, the ocean water temperature, can be measured by lidar remote sensing technique as we have recently shown in Svalbard (Norway) [22]. These data are quite important to calibrate the ocean temperature maps acquired from satellite images.

From the paper [23] it is clear that the Arctic region was relatively free from the rainbow oil film around ten years ago. However, the transportation of oil from Russian oil platforms (including platform "Prirazlomnaya") together with active oil tankers transport along the Northern Sea Route may lead to the Arctic water pollution by oil in the nearest future. Solution to this problem is to establish a reliable water surface monitoring system, which can be placed in ports and in the air, and should include new generation lidar systems [3, 22]. It can be a necessary step in keeping arctic water areas clean from pollution for the future use [24].

The 21st UN Conference on climate change (United Nations Framework Convention on Climate Change (COP-21)) and 11th meeting under the framework of Kyoto Protocol (CRP-11), which was held in France in December 2015, were aimed at signing and implementing an international agreement to maintain an increase in the average temperature of the planet below 2°C, which should be applicable for all countries [25]. Environmental catastrophes, such as the accident at the Deepwater Horizon oil platform in the Gulf of Mexico on April 20, 2010, can lead, as it is shown clearly in this paper, to local warming of the ocean by a factor of several times higher than 2°C, and can be the main reason for uncontrolled global processes, especially in the Arctic, which already heats up twice as fast as the entire globe.

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