O‘ZBEKISTON RESPUBLIKASI OLIY TA’LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

MIRZO ULUG‘BEK NOMIDAGI O‘ZBEKISTON MILLIY UNIVERSITETINING JIZZAX FILIALI

RAQAMLI JAMIYATDA FAN VA TA’LIMNING INTEGRATSIYALALASHUVI: MATEMATIKA, IQTISOD, PEDAGOGIKA VA PSIXOLOGIYANING YANGI YONDASHUVLARI

mavzusidagi Respublika ilmiy-texnik anjuman materiallari to‘plami

(2026-yil 20-21-aprel)

JIZZAX-2026

Raqamli jamiyatda fan va ta’limning integratsiyalalashuvi: matematika, iqtisod, pedagogika va psixologiyaning yangi yondashuvlari. Respublika ilmiy-texnik anjuman materiallari to‘plami – Jizzax: O‘zMU Jizzax filiali Amaliy matematika kafedrasi, 2026-yil 20-21-aprel 505-bet.

Respublika miqyosidagi ilmiy-texnik anjuman materiallarida zamonaviy kompyuter ilmlari va muhandislik texnologiyalari sohasidagi innovatsion tadqiqotlar aks etgan.

Globallashuv sharoitida davlatimizni yanada barqaror va jadal sur’atlar bilan rivojlantirish bo‘yicha amalga oshirilayotgan islohotlar samarasini yaxshilash sohasidagi ilmiy-tadqiqot ishlariga alohida e’tibor qaratilgan. Zero iqtisodiyotning, ijtimoiy sohalarni qamrab olgan modernizatsiya jarayonlari, hayotning barcha sohalarini liberallashtirishni talab qilmoqda.

Ushbu ilmiy ma’ruza tezislari to‘plamida mamlakatimiz va xorijlik turli yo‘nalishlarda faoliyat olib borayotgan mutaxassislar, olimlar, professor-o‘qituvchilar, ilmiy tadqiqot institutlari va markazlarining ilmiy xodimlari, tadqiqotchilari, magistr va talabalarning ilmiy-tadqiqot ishlari natijalari mujassamlashgan.

Mazkur to‘plamga kiritilgan ma’ruza tezislarining mazmuni, undagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligi hamda tanqidiy fikr-mulohazalar, keltirilgan takliflarga mualliflarning o‘zlari mas’uldirlar.

Yechish: $y(t) = 20 + 30 \cdot e^{-0,03t}$ kg. $t \to \infty$da $y \to 20$ kg, ya'ni konsentratsiya kirayotgan eritmaning konsentratsiyasiga tenglashadi.

Har qanday amaliy masalani yechish uchun quyidagi to‘rt bosqichli algoritm tavsiya etiladi: 1-bosqich - Model tuzish: asosiy o‘zgaruvchilarni aniqlash; 2-bosqich - Tenglama hosil qilish: $y' + P(x)y = Q(x)$ standart ko‘rinimiga keltirish; 3-bosqich - Yechish: integrallovchi ko‘paytuvchi yoki Bernulli usuli orqali umumiy va xususiy yechimni topish; 4-bosqich - Talqin qilish: natijani fizik yoki geometrik ma'noda izohlash va tekshirish.

FOYDALANILGAN ADABIYOTLAR

1. Boyce W.E., DiPrima R.C. Elementary Differential Equations and Boundary Value Problems. - Wiley, 2017.
2. Filippov A.F. Differensial tenglamalar to‘plami. - Moskva: Nauka, 1992.
3. Simmons G.F. Differential Equations with Applications and Historical Notes. — McGraw-Hill, 1991.
4. Stepanov V.V. Differensial tenglamalar kursi. - Moskva: GIFML, 1959.
5. Tixonov A.N., Samarskiy A.A. Matematik fizika tenglamalari. - Moskva: Nauka, 1977.
6. Toshmatov N.A. Differensial tenglamalar va ularning tatbiqlari. - Toshkent: O‘zbekiston, 2005.

ON SOME SPECIFIC FEATURES OF HIGH-FREQUENCY SOUND DISPERSION IN A SOLUTION WITH A PECULIAR POINT

L.M. Sabirov, D.I. Semenov, H.M. Begaliyev
Institute of Engineering Physics, Samarkand State University, Samarkand, Uzbekistan (e-mail: denis.samarkand@gmail.com)

Aqueous solutions of methyl derivatives of pyridine with concentrations 0.06 to 0.08 mole fraction (MF) at the normal air pressure and temperature t0 ≈ 70°C have a minimum of thermodynamic stability [1] (a peculiar point in the temperature–concentration phase diagram) and thus are convenient for studying structural transformations in the vicinity of the peculiar point.

Earlier ultra- and hyperacoustic parameters of a solution belonging to this class (aqueous solution of 3-methylpyridine) were investigated in our laboratory [2-4]. Temperature dependences of the ultra- and hypersound velocities in the temperature range from 20 to 80 °C unambiguously pointed to existence of positive sound velocity dispersion in the vicinity of the singular point. The analysis of the experimental results for this solution obtained at the frequency about 2.6 GHz gives grounds to assume that negative velocity dispersion (i.e., a decrease in the velocity with increasing sound frequency) may also exist in the vicinity of the singular point in a narrow hypersound frequency range. To verify this assumption, it is necessary to investigate temperature dependences of the speed of sound in the aqueous solution of 4-methylpyridine (4MP) with the concentration 0.06 MF corresponding to the peculiar point.

In this paper, we discuss the results of the first study of the frequency dependence of the hypersound velocity dispersion in aqueous solutions of 4-methylpyridine (4MP) with concentration *x*=0.06 MF (the peculiar point). As compared with our previous investigations, the sound frequency range is appreciably wider, from 5.4 MHz to 6.1 GHz.

The ultrasound velocity for the frequency of 5.4 MHz was measured by the acoustic-optical method based on laser radiation diffraction by ultra- sound waves. The hypersound velocity in the frequency range from 2.6 to 6.1 GHz was determined from the frequency shift of the fine-structure component of the Rayleigh light scattering line (Brillouin component) for three scattering angles 45, 90 and 135°.

The results of the studies of the speed of sound at frequencies from 5.4 MGz to 6.1 GHz show:

1) in the frequency range from 5.4 MHz to 4.8 GHz there is a positive dispersion of the speed of sound; 2) in a narrow frequency interval from 4.8 to 6.1 GHz a negative dispersion of the speed appears; 3) the magnitude of the dispersion (both positive and negative) is practically independent of the temperature of the solution in the entire studied temperature range.

The analysis of the frequency dependence of the speed of sound, observed in the range from ultrasonic to hypersonic frequencies, was carried out based on the following experimental results:

1) in the frequency range from 5.4 MHz to 4.8 GHz the behavior of the speed corresponds to a positive dispersion caused by the process of relaxation of bulk viscosity;

2) the speed of hypersound with a frequency of 6.2 GHz is lower as a result of the existence of negative dispersion.

The magnitude of the positive dispersion of the speed of sound in the frequency range from 5.4 MHz to 4.8 GHz was calculated using the formula $\frac{\Delta V}{V} = \frac{V_1 - V_2}{V}$, where V_1 and V_2 are the speeds of hypersonic (f = 4.8 GHz) and ultrasound (f = 5.4 MHz), respectively, and $V = (V_1 + V_2)/2$ is the average speed in this frequency range. The same formula was used to calculate the negative dispersion value. The resulting temperature dependences of the velocity dispersion are shown in Figure 1. As can be seen from the figure, the positive dispersion is approximately 4% and depends weakly on the solution temperature. The negative dispersion is approximately 3% and is also virtually independent of the solution temperature.

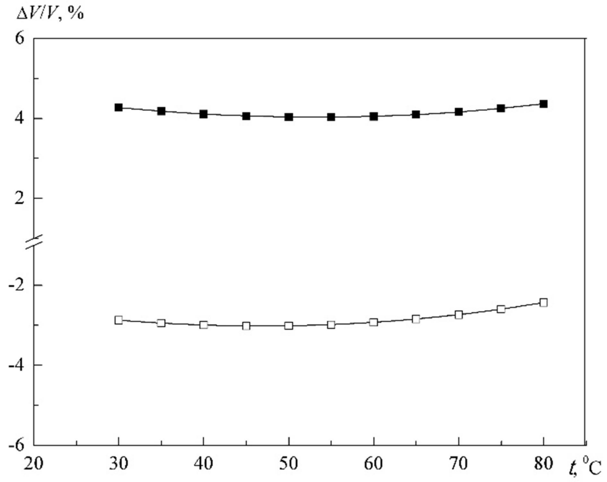

Fig.1. Temperature dependences of the dispersion of the speed of sound in the frequency range from 5.4 MHz to 4.8 GHz (upper curve) and in the frequency range from 4.8 to 6.1 GHz (lower curve)

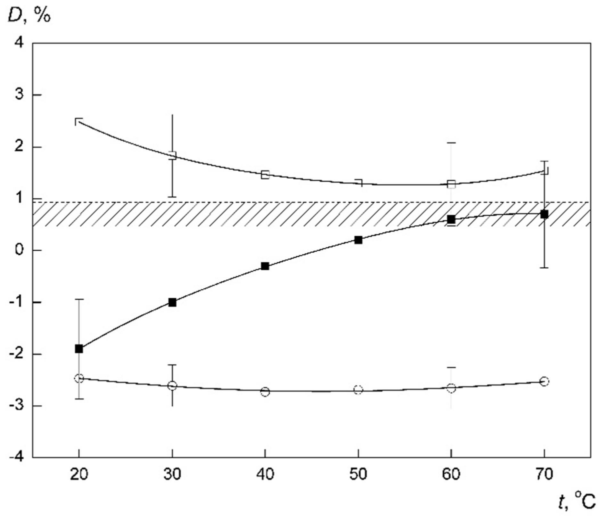

Fig.2. Temperature dependence of the dispersion in aqueous solutions of 4MP with non-electrolyte concentrations of 0.06 (○) (this work), 0.08 (■), and 0.03 (□) MF. The shaded area is the set of regular dispersion values.

Figure 2 shows, for comparison, the data we obtained earlier for the same solution, with concentrations slightly below and above the peculiar point.

The calculation of the parameters of the relaxation process of bulk viscosity, leading to a positive dispersion of the speed of sound, was carried out in accordance with the formulas of the relaxation theory

$$V^2 = \frac{\Omega^2\tau^2}{1+\Omega^2\tau^2}\left(V_\infty^2 - V_0^2\right) + V_0^2$$

Here □, □, V_0 and V_∞ are the frequency, acoustic relaxation time, and the limiting values of velocities, respectively. The results of the study and calculations based on them show that: 1) in an aqueous solution of 4MP, there is a relaxation process, the acoustic relaxation time □□of which is □□□$\times 10^{-11}$ s, and 2) the values of the speed of ultrasound and hypersound at frequencies of 5.4 MHz and 4.8 GHz are close to the limiting speeds V_0 and V_∞.

The magnitude of positive dispersion and its temperature behavior are characteristic of low-viscosity liquids; this phenomenon has been observed by many authors and is due to the process of relaxation of bulk viscosity [5].

At the same time, a new physical phenomenon - negative dispersion of the speed of sound - has been discovered in the relatively narrow frequency range from 4.6 to 6.2 GHz. In this frequency range, the speed of sound decreases with increasing frequency. The unusual nature of the change in dispersion in a relatively small frequency range indicates that, to explain both the negative and positive dispersion of the hypersonic velocity observed in the solution we studied, it is necessary to involve physical mechanisms not associated with the relaxation of bulk viscosity.

The negative dispersion of hypersonic speed observed in our experiments may be due to the heterogeneity of the internal structure of the solution due to the formation of molecular aggregates in it, bound by elastic forces. In this case

$$V = V_0\left(1 + \frac{2\pi^2 f^*}{V_0^2\Lambda^2}\right)$$

where V_0 is the speed of sound at low frequency, □ is the wavelength of sound, and f^* is a quantity characterizing the intermolecular interaction. The change in the speed of sound V relative to V_0 will be determined by the sign of f^*, which depends on the nature of the intermolecular interactions. For example, in a system of molecular aggregates bound together by elastic forces, $f^*<0$, and the dispersion will be negative. When estimating the magnitude of dispersion, it must be assumed that $|f^*|\sim(V_0\ r)^2$, where r is the distance at which molecular interaction is significant (correlation radius or aggregate size).

Our estimates of the size of the associated aggregate r were found to be of the order of 100 Å, which is consistent with the sizes of aggregates observed in other similar solutions by other methods .Thus, for example, in the work [7], based on measurements of the concentration dependences of the spectral intensity of the Rayleigh line and calculations of the correlation functions of the electric field of scattered light, the sizes of clusters in aqueous solutions of tertiary butyl alcohol and 2-butoxyethanol at a temperature of 40 ^{o}C and in the range of non-electrolyte concentrations from 0.02 to 0.2 molar fractions are estimated at 50 Å.

Thus, in our experiments it has been established that negative dispersion, observed for the first time in the vicinity of the peculiar point of 4MP-Water solution is of non-relaxation origin and is caused by the presence of ordered regions ("clusters") in the solution. As a result, the propagation of high-frequency sound in a spatially inhomogeneous medium is accompanied by an additional contribution to the sound velocity due to the spatial dispersion mechanism. The size of the spatial inhomogeneity, determined from the magnitude of negative dispersion, is on the order of 10 nm and is independent of the solution temperature. This proves that the ordered regions are not fluctuation-induced formations, but rather represent a local element of the solution structure.

References

1. M.A. Anisimov, *Critical Phenomena in Liquids and Liquid Crystals*; Nauka: Moscow, Russia, 1987. (In Russian)
2. L.M. Kashaeva, L.M. Sabirov, Sh. Sidikov, T.M. Utarova, and Ya.T. Turakulov, “Dispersion of High-Frequency Sound in an Aqueous Solution of β-Picoline,” Acoust. Phys. **44** (3), 312 (1998).
3. N.F. Bunkin, V.S. Gorelik, L.M. Sabirov, D.I. Semenov, and Kh. S. Khaidarov, “Frequency shift of Rayleigh line fine structure components in a water solution of 4-methylpyridine as a function of temperature, concentration, and light scattering angle,” Quantum Electron. **40** (9), 817 (2010).
4. L.M. Sabirov, D.I. Semenov, and Kh.S. Khaidarov, “Concentration dependence of the hypersonic velocity dispersion in aqueous solutions of 4-methylpyridine,” Phys. Wave Phenom. **19** (3), 184 (2011).
5. I.L. Fabelinskii, *Molecular Scattering of Light*, Plenum, New York, 1968.
6. N. Ito, T. Fujiyama, and Y. Udogawa, “Study of Local Structure Formation in Binary Solutions of 2-Butoxyethanol and Water by Rayleigh Scattering and Raman Spectra,” Bull. Chem. Soc. Jpn. **56** (2), 379 (1983).

MANTIQIY VA TANQIDIY FIKRLASHNI RIVOJLANTIRISHDA MATEMATIK TAFAKKURNING ROLI

Sodiqova Vazira Yaxyoqul qizi
O‘zbekiston Milliy Universiteti Jizzax filiali 1-kurs magistranti
Tel:+998991946673
Email:sodiqovavazira3@gmail.com

Hozirgi globallashuv va raqamli jamiyat sharoitida o‘quvchi-talabalarning mantiqiy va tanqidiy fikrlash qobiliyatlarini rivojlantirish ta’lim tizimining ustuvor vazifalaridan biri hisoblanadi. Chunki zamonaviy jamiyat faqat bilimga ega bo‘lgan emas, balki mustaqil fikrlay oladigan, muammoli vaziyatlarda to‘g‘ri qaror qabul qila oladigan va mavjud ma’lumotlarni tahlil qilib, ulardan samarali foydalana oladigan shaxslarni talab etadi. Mantiqiy va tanqidiy fikrlash shaxsning intellektual yetukligini ifodalovchi muhim omil bo‘lib, u orqali inson borliqni chuqur anglaydi, sabab-oqibat bog‘lanishlarini ko‘ra oladi va asoslangan xulosalar chiqaradi.

Mantiqiy fikrlash voqea-hodisalar o‘rtasidagi bog‘lanishlarni aniqlash, ularni tizimli ravishda tahlil qilish va umumlashtirishni anglatadi. Tanqidiy fikrlash esa berilgan ma’lumotlarni shubha ostiga qo‘yish, ularni tekshirish, muqobil variantlarni solishtirish va eng maqbul qarorni tanlashni o‘z ichiga oladi. Ushbu ikki fikrlash turi o‘zaro uzviy bog‘liq bo‘lib, ta’lim jarayonida birgalikda rivojlantirilishi lozim. Bu esa o‘quvchi-talabalarning bilimni nafaqat o‘zlashtirish, balki uni amaliyotda qo‘llash, tahlil qilish va baholash qobiliyatini oshiradi.

Ta’lim jarayonida matematika fanining o‘rni beqiyosdir. Matematik tafakkur o‘quvchilarda aniqlik, izchillik, asoslanganlik va tizimlilik kabi muhim sifatlarni shakllantiradi. Ayniqsa, muammoli masalalar orqali o‘quvchilarning mantiqiy va tanqidiy fikrlash qobiliyatlarini rivojlantirish mumkin. Bunday masalalar o‘quvchilarni nafaqat hisoblashga, balki fikrlashga, tahlil qilishga va xulosa chiqarishga o‘rgatadi.

Masalan, 6-sinf matematika darsligidan olingan quyidagi masalani ko‘rib chiqamiz: ikkita ishchi birgalikda ma’lum bir ishni 6 kunda bajaradi. Agar birinchi ishchi ushbu ishni yolg‘iz o‘zi 10 kunda bajara olsa, ikkinchi ishchi shu ishni necha kunda bajaradi? Ushbu masalani yechishda avvalo mantiqiy yondashuv qo‘llaniladi. Umumiy ish bir birlik deb olinadi va ishchilarning unumdorligi aniqlanadi. Ikki ishchi birgalikda bir kunda ishning $\frac{1}{6}$ qismini bajaradi,birinchi