

UDC 533.9.004.14; 621.039.6

A. Drobyshev\*, A. Aldiyarov, Zh. Nurekeyev, A. Tychengulova

Al-Farabi Kazakh National University, Almaty, Kazakhstan,

\*E-mail: Andrei.drobyshev@kaznu.kz

### Thermally stimulated transformations in thin films of cryovacuum condensates of methane

Solid methane belongs to a group of crystals which contains molecules of hydrogen, whose macroscopic properties (thermal expansion, etc.) are greatly caused by spin interaction of nucleus of hydrogen. In particular, the methane molecule, which has four protons with spin  $I = 1/2$ , has three total spin modifications: para-, ortho- and meta- states with three values of the total spin moments of 0, 1 and 2, accordingly.

**Key words:** Methane, spin, thin film condensation.

А. Дробышев, А. Алдияров, Ж. Нурекеев, А. Тыченгулова

### Термостимулированные преобразования в тонких пленках криовакуумных конденсатах метана

Твердый метан принадлежит к группе кристаллов, которые содержат молекулы водорода, чьи макроскопические свойства (тепловое расширение, и т.д.) в значительной степени вызваны спиновым взаимодействием ядер водорода.

**Ключевые слова:** метан, спин, тонкие пленки, конденсат.

А. Дробышев, А. Алдияров, Ж. Нурекеев, А. Тыченгулова

### Криовакуумды метан конденсаттарындағы жұқа үлдірлерде болатын термынтандырылған түрленулер

Қатты метан құрамында сутегі ядроларының спиндік әсерлесулерінің арқасында (жылулық кеңею және т.б.) қасиеттері өзгерген сутегісі бар кристалдар тобына жатады.

**Түйін сөздер:** метан, спин, жұқа үлдір, конденсат.

Solid methane belongs to a group of crystals which contains molecules of hydrogen, whose macroscopic properties (thermal expansion, etc.) are greatly caused by spin interaction of nucleus of hydrogen. In particular, the methane molecule, which has four protons with spin  $I = 1/2$ , has three total spin modifications: para-, ortho- and meta-states with three values of the total spin moments of 0, 1 and 2, accordingly. As a result of conversion between these states, an equilibrium concentration ratios set corresponding to the temperature of the system. Identification of connection between the speed of conversion and conditions of formation and existence of solid methane is an object of the research the last 40 years [1, 2].

After this our experimental results will be shown. Despite its simplicity from the point view

of organic chemistry, molecule of methane is a quantum object. We have carried out researches of gas hydrates as they are potential energy sources. In the course of research of thin films of methane cryocondensates we have found unusual optical properties in IR-range.

Molecules that possess equivalent nuclei exhibit different nuclear spin states. Well-known case is the nuclear spin isomers of hydrogen molecule. Hydrogen molecule with the nuclear spin number 1 is called orthohydrogen, and those with nuclear spin number 0 is called parahydrogen (Fig.1).

Our object of study is methane molecules. Methane has 4 equivalent nuclei. And spin numbers of isomers are 2, 1 and 0. Last 30-40 years methane has been actively studied. We focus on thin films of

methane at high vacuum. There is an equilibrium of concentrations between nuclear spin states. According to Yuki Miyamoto ratio of concentrations at 4K is 0:1:9. If isomers at equilibrium, and then

we change the temperature, isomers will strive to the new equilibrium. This striving process is called nuclear spin conversion. Relaxation time can vary within wide range (Fig.2)..

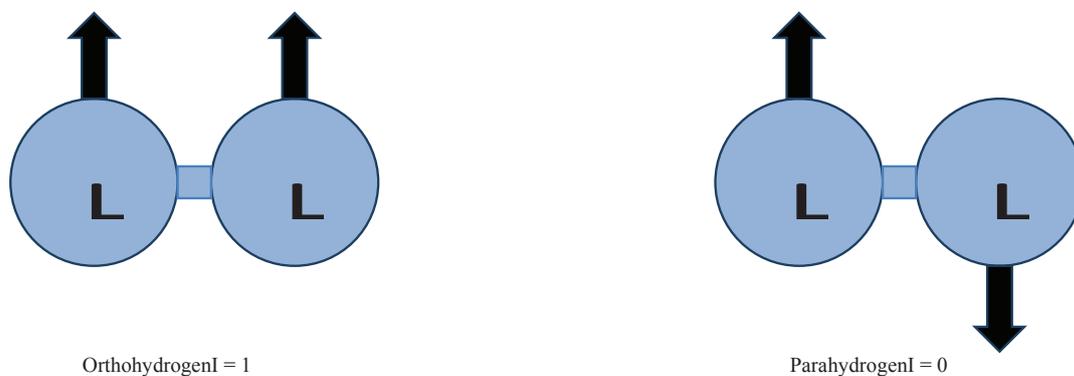


Figure 1 – Nuclear spin isomers of  $H_2$

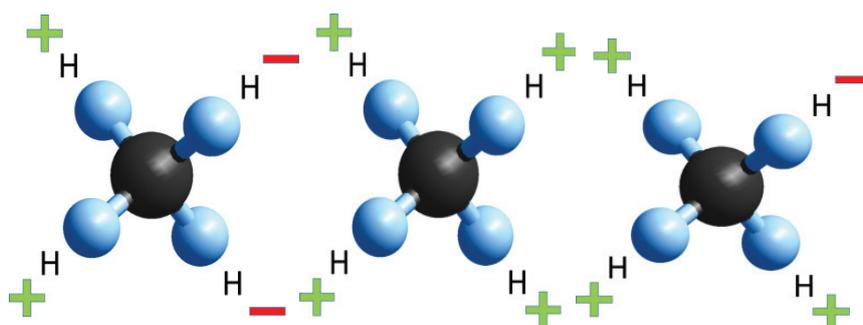


Figure 2

Here you can see some possible transitions between energy levels. It shows us couplings between rotational states and nuclear spin states. Also vibrational states and spin states are coupled according to Mr. Nijman. It is possible due to spin-phonon interaction.

Changing in the position of absorption band of methane cryocondensateslibration varying thickness. Condensation temperature is  $T = 16$  K.

In this report the results of optical researches of thin films of methane cryovacuum condensates, which were formed at a temperature of a substrate of  $T=16$  K and subjected further to thermostimulated influences, are offered to discussion. The obtained features allow to make the assumption that during temperature increase the sample undergoes the transformations caused by spin conversion.

#### References

- 1 Yuki Miyamoto, Mizuho Fushitani, Daisuke Ando, and Takamasa Momose. *J. of Chem. Phys.* 114502 (2008)
- 2 A.J. Nijman, A John Berlinsky // *Phys. Rev. Let.*, 38, 408 (1977)