

Из (16) следует, что при $\Delta(x_0) = 0$ решение системы (26) является и периодическим решением уравнения (2). Поэтому, существование периодических решений уравнения (2) связано с существованием нулей функции $\Delta(x_0)$. Вопрос существования нулей функции $\Delta(x_0)$ решается исходя из функции $\underline{\Delta}_m(x_0)$ или $\overline{\Delta}_m(x_0)$.

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РЕЗЮМЕ. Бу маколада икки томонлама яқинлаштишлар усули Фредгольм типдаги интегро-дифференциал тенгламаларнинг даврий ечимларини ўрганиш учун қўлланилади.

РЕЗЮМЕ. В данной работе метод двухсторонних приближений применяется к исследованию периодических решений интегро-дифференциальных уравнений типа Фредгольма.

SUMMARY. In this paper, the method of two-sided approximations is applied to the study of periodic solutions of integro-differential equations of the Fredholm type.

STUDY ON THE COUPLING RELATIONSHIP OF POPULATION, RESOURCES, ENVIRONMENT AND ECONOMY IN HOHHOT-BAOTOU-ORDOS-ULANQAB URBAN AGGLOMERATION

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Таянч сўзлар: аҳоли-ресурслар-атроф-муҳит-иктисодий, алоқанинг координацион модели, фазо-вақт алоқаси, шаҳар агломерацияси.

Ключевые слова: население-ресурсы-окружающая среда-экономика, координационная модель связи, пространственно-временная связь, городская агломерация.

Key words: population-resources-environment-economy, the coupling coordination model, spatio-temporal coupling, urban agglomeration.

Introduction. The coupling and coordinated development among population, resources, environment and economic system is an important issue for regional social economies to achieve high-quality sustainable development. Vigorously promoting the coupling and coordinated development of population, economy, resources and environment system in The HBOUUA is a major issue concerning the new development period of the 14th Five-Year Plan of Inner Mongolia Autonomous Region and taking a new path of high-quality development with ecological priority and green development as the guidance. Located in the central part of The Autonomous Region, HBOUUA is an important plate for ecological protection and high-quality development of the Yellow River Basin, a key development area and a core area for economic development of Inner Mongolia Autonomous Region, and plays an important strategic role in the overall high-quality development of the Autonomous Region and its comprehensive integration into domestic and international markets.

Literature review. Scholars at home and abroad have made many beneficial explorations and practices based on the practical application of coupling coordination theory in population, economy, society, resources and environment, and have always believed that the coordinated development of population, economy, resources and environment is the fundamental path to achieve sustainable development. Foreign studies on the relationship between population, resources, environment and economic development mainly focus on three aspects: [1] The relationship between population and economic development, focusing on the pessimistic population theory represented by Malthus (Malthus 1978), Nelson (Pearl 1920, p.278), Cole and Hoover (Ehrlich., Brassards., Sharp 1972, p.245), which holds that population growth is not conducive to economic development; the population optimism theory represented by Keynes (Board 2002), Hansen (Beckerman 1992, p.84) and Simon (Hu 1980) believes that population growth will drive economic growth. The relevant theories of population and economic development are represented by Inkanan (Simon 1986), Wixel (Pearce., Barber., Miranda 1990), Alfred Sauve (Hettinger and Muthukumara 2000, p.448). And Gora Olin (Hung., Chang., Blackburn 1994) holds that

there is a variable correlation between population and economic development [2].

Study area. HBOUUA is situated in the central and western part of Inner Mongolia with an administrative area of 186,200 square kilometers, accounting for 15.7% of the whole region. There are 37 county-level administrative units under the jurisdiction of the urban agglomeration, including 13 administrative districts and 24 administrative banner counties. The city cluster enriches resources, with proven coal reserves of 265.20 billion tons in 2020, accounting for 51.2 percent of the region. Iron reserves of 2.01 billion tons, accountable for 47.6% of the region. In 2020, the population of permanent residents was 10.015 million, being accountable for 41.6% of the total population of the region, and the proportion of permanent residents was 2.77% higher than that of 2010 [4]. The urbanization rate of permanent residents reached 77.39%, among which the urbanization rate of Hohhot was 79.15%. Baotou and Ulanqab were 86.16%, 77.45% and 59.7% respectively [5]. In 2020, the GDP of HBOUUA is ¥994.86 billion, accounting for 57.5% of the whole region, among which the three cities of Hohhot Baotou Ordos account for 52.5%.

Results and Analysis. From the comprehensive analysis, it can be seen that the time series evolution trend of the comprehensive development index of HBOUUA subsystems of population, economy, resources and environment shows great differences, which can be divided into two basic types: fluctuation rise and fluctuation decline. Gradually began to develop to the evolutionary stage of coordinated development of economic development and population structure, gradually from the past extensive economic development mode to pay attention to the connotation of high-quality development mode for adaptive transformation. At the same time, the sustained growth of industrial waste water, smoke, dust and other environmental pollution problems highlighted increasingly, the contradiction between regional economic development and the natural ecological environment has become increasingly acute. Since the global financial crisis in 2008, HBOUUA has paid ample attention to the protection and construction of natural ecological environment [3]. The provincial economic and energy

structure has been optimized and adjusted orderly year by year, and the regional economic and industrial structure has achieved green transformation and upgrading progress year by year, especially after 2012.

Characteristics of spatial pattern evolution of comprehensive development level. As can be seen from the comprehensive analysis, the spatial pattern of comprehensive development level of HBOUUA subsystem varies greatly, among which, the spatial difference of comprehensive development level of population subsystem is obvious. Hohhot, as the capital city of Inner Mongolia Autonomous Region, has a high degree of urban preparedness, a strong ability to gather regional industrial and economic resources and attract talents. The comprehensive development index of population subsystem has increased by 0.6681 in 16 years, showing a good development trend [6]. Relying on its advantages in energy resources, Ordos continues to accelerate its urban economic development, showing a momentum of rapid development since 2003. The comprehensive development index of population subsystem has increased from 0.0586 in 2003 to 0.8489 in 2018. The growth rate reached 0.7903, and the future development trend is good. As an iron and steel industrial base built earlier in China, Baotou has been greatly influenced by national macro policies. Since 2008, Baotou has experienced the impact of industrial capacity reduction policies, and the industrial structure of urban economy has entered a new stage of optimization and adjustment. Since 2003, it has shown a negative trend of population sub-system comprehensive development index. It can be seen that the change trend of the coupling degree of population, economy, resources and environment in HBOUUA shows a wave of 50% oscillation fluctuation, and the coupling degree reaches the highest point of 0.81462 after three periods of initial rise and then decline from 2003 to 2010 [5]. From 2010 to 2018, the coupling degree increased firstly and then decreased three times, and the coupling degree tended to be stable after 2016. From 2003 to 2019, 10 evolutionary development processes including antagonism - running-in - high level coupling - running-in - high level coupling were experienced, and the maximum amplitude of coupling degree fluctuation reached 0.3723. After 2010, the amplitude of coupling degree fluctuation decreased year by year. HBOUUA is the core area of high-quality development along the Yellow River basin in Inner Mongolia. Since the 18th National Congress of the Communist Party of China, the Government of The Inner Mongolia Autonomous Region has paid great attention to the construction of ecological civilization and the protection of the ecological environment in Inner Mongolia [9]. It has continuously strengthened the protection and construction, improved the level of ecological environmental protection, and made efforts to build an important ecological barrier in northern China. The continuous promotion of ecological construction and high-quality development in The Inner Mongolia Autonomous Region along the Yellow River has achieved remarkable results in recent years, which is completely consistent with the evolution trend of HBOUUA coupling coordination degree [8]. The interactive development relationship between HBOUUA population, economy, resources and environment has undergone important changes.

The development mode of disordered interaction among subsystems has gradually evolved to a higher coordinated development stage of synergistic development and mutual promotion. The coupling degree of the system has experienced a process of repeated interaction adjustment among subsystems and reached a high level of coupling development stage in 2016 [11]. HBOUUA earnestly implements the major national strategy of ecological protection and high-quality development in the Yellow

River Basin, and walks out a new way of high-quality development with ecological priority and green development as orientation, which is of great significance to Inner Mongolia along the Yellow River Basin and the whole country.

Spatial evolution characteristics of urban agglomeration coupling degree

In order to further analyze the spatial differentiation of the coupling degree of population, economy, resources and environment in HBOUUA from the municipal scale, four time nodes in 2003, 2008, 2013 and 2018 were selected to plot the coupling degree of each city. As can be seen from statistical data, the coupling degree of Hohhot, Ordos and Ulanqab showed an increasing trend from 2003 to 2018, while Baotou showed a fluctuating downward trend, which was basically consistent with the trend of HBOUUA. Although the coupled degree of the system is developing well on the whole, there are still obvious spatial differences between cities in spatial evolution [10]. From 2003 to 2008, the coupling degree of Ordos increased the fastest, increasing by 0.572, from low level coupling to high level coupling, Hohhot and Ulanqab developed from antagonistic stage to Running-in stage, Baotou from high level coupling to Running-in stage.

From 2013 to 2018, Ordos showed a strong rebound and rose to first place, with Hohhot and Ulanqab showing a common trend of growth, synchronous development to a high level of coupling, Baotou showing a rapid downward trend, will come to the Running-in stage. Ordos, Hohhot and Ulanqab though is in high coupling phase, but still has a big gap between high quality coupling, the population - economy - resources - environment, the index score of each subsystem is low, the growth of the continued ascension of each index factor score ability, and realize the coordinated development between subsystems is the inevitable path to achieve high quality coupling.

It can be seen that the change trend of the coupling coordination degree of population, economy, resource and environment in HBOUUA shows an evolution process of dynamic fluctuation rising and tending to be stable. After experiencing a period of fluctuation from 2003 to 2005, it shows a slow growth trend and reaches the highest point of coupling coordination degree of 0.6724 in 2010 [9]. Since 2009, it has maintained a moderate coordination stage between 0.62-0.67 for a long time. From 2003 to 2018, it experienced two evolutionary development processes of mild disorder and moderate coordination.

It was in the stage of mild disorder from 2003 to 2006, stable in the stage of moderate coordination from 2007 to 2018, and showed a rapid growth stage from 2003 to 2010. The maximum fluctuation amplitude of coupling degree reached 0.2589. The average annual growth rate is 0.0324% [11]. The score of coupling coordination degree always lags behind that of coupling degree, and there is still a big gap between the score of coupling coordination degree and achieving high-quality coordination, which is relatively consistent with the overall development status of HBOUUA. HBOUUA is the "locomotive" of the economic and social development of the Autonomous Region. The proportion of the permanent population and regional economic aggregate in the whole region continues to rise, and the population and economic carrying capacity of the urban agglomeration keeps increasing. HBOUUA has become the main engine for economic and social development, ecological civilization construction, reform and innovation, and opening-up of the Autonomous Region. The coordinated development of population, economy, resources and environment subsystems has not yet formed an efficient collaborative development force, ecological transportation has shortcomings, and the development potential of urban agglomeration needs to be exploited urgently.

Among them, Ordos had the largest growth with an increase of 0.4583 and an annual growth rate of 0.0286%. The overall development of system coupling coordination degree is good, and the spatial evolution pattern shows that there are obvious spatial differences among cities. From 2008 to 2013, Hohhot, Baotou Ordos and Ulanqab all showed a growth trend, and reached moderate coordination, showing a good development trend. From 2013 to 2018, Hohhot and Ordos continued to show an increasing trend, and at the same time reached a good coordination state, and have now developed into the first echelon of HBOUUA. Both Baotou and Ulanqab showed a downward trend, and Baotou fell faster, and both were in a moderate coordination state. Although Hohhot and Ordos have been in a good coordination state, there is still a big gap between them, which also indicates that Hohhot and Ordos still have more space for development in the future.

Conclusions. The urbanization process of HBOUUA continues to advance rapidly, and the contradiction between

population, resources, environment and economic system becomes increasingly acute. This paper adopts the method of system theory to construct the comprehensive evaluation index system of population, resources, environment and economy. Based on the minimum information entropy weight method, coupling degree, coupling coordination degree and other models, the comprehensive development level of the HBOUUA system from 2000 to 2019, the temporal evolution characteristics of coupling coordination degree and the spatial evolution pattern of coupling coordination degree were deeply discussed. The coupling coordination degree of Ordos improved the most, followed by Hohhot, and attained a good coordination state in 2018. The coupling coordination degree of Baotou and Ulanqab has a weak ability to upgrade, and has been in a moderate coordination state for a long time. The coupling coordination degree of Baotou and Ulanqab still has a large space for improvement in the future.

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РЕЗЮМЕ. Мақолада айтилишича, аҳоли, ресурслар, атроф-муҳит ва иқтисодий тизимнинг уйғунлиги ва мувофиқлаштирилган ривожланиши минтақавий сифат ривожланишининг муҳим қисмидир. ХБОУУАда аҳоли-ресурслар-атроф-муҳит-иқтисодиёт тизимининг улашиш даражаси ишга тушириш босқичидан юқори даражадаги улашиш даражасига кўтарилди ва алоқани мувофиқлаштириш даражаси бироз тартибсизликдан ўртача мувофиқликка ўзгарди.

РЕЗЮМЕ. В статье говорится, что сопряжение и скоординированное развитие населения, ресурсов, окружающей среды и экономической системы является важной частью регионального качественного развития. Степень связанности системы население-ресурсы-окружающая среда-экономика в HBOUUA повысилась со стадии обкатки до высокого уровня связи, а степень координации связи изменилась с легкой неупорядоченности на умеренную согласованность.

SUMMARY. This article states that the coupling and coordinated development among population, resources, environment and economic system is the important part of regional high quality development. The coupling degree of population-resources-environment-economy system in HBOUUA rised from running-in stage to high level coupling, and the coupling coordination degree changed from mild disorder to moderate coordination.

DIFFUZIYA USULI BILAN LEGIRLANGAN KREMNIYDA RUX VA SELEN ATOMLARINI ELEKTROFIZIK XUSUSIYATLARINI TAHLIL QILISH

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Tayanch soʻzlar: diffuziya, rentgen fazasi tahlili, kremniy, selen, relyef, birikmalar, nanokristal, refleks, klaster, tuzilishi.

Ключевые слова: диффузия, рентгенофазовый анализ, кремний, селен, цинк, рельеф, соединения, нанокристалл, рефлекс, кластер, структура.

Key words: diffusion, X-ray phase analysis, silicon, selenium, zinc, relief, compounds, nanocrystal, reflex, cluster, structure.

Zamonaviy mikro va nanoelektronika rivoji energiya tejovchi xususiyatlarga va yangi funksiyalarga asoslangan yangi materiallar va qurilmalarni yaratishni talab qiladi. Shu nuqtayi nazardan, nanostruktiv kremniy, begona atomlar bilan legirlangan kremniy katta qiziqish uygʻotadi. Bunday materiallarni turli xil usullar bilan atomlar klasterlarini shakllantirish yoʻli bilan olish mumkin, ammo tadqiqotlar shuni koʻrsatdiki, olingan materiallar zamonaviy nanoelektronikada muammolarni toʻliq hal qilishga imkon bermaydi. Bu, asosan, yuqori konsentratsiyaga bogʻliq emas, shuningdek, konsentratsiyani va kremniydagi aralash nanoklastlarning tarkibini nazorat qilish qobiliyati emas. Shuning uchun, kremniy elementar panjarasida II va VI guruh elementlarini oʻz ichiga olgan ikkilik klasterlarning

yangi turining shakllanishi katta qiziqish uygʻotadi. Adabiy maʼlumotlardan maʼlum boʻlishicha, kremniydagi bu ikkilik atomlar yuqori eruvchanlikka ega ($N = 10^{20} - 10^{21} \text{ cm}^{-3}$). Alohida holatda bu atomlar kichik donor va qabul qiluvchi darajalarni yaratadi, kremniy esa oʻz navbatida valentlik zonasida oʻtkazuvchanlik zonasida qoʻshimcha elektronlar hosil qiladi [1]. Shu nuqtayi nazardan, ushbu tadqiqotning maqsadi, kremniy yuzasida olingan diffuziya qatlami ($(\text{Si}_2)_{1-x}(\text{ZnSe})_x$) rentgenofaza tahlillari yordamida sirt holatini oʻrganishdir. Tuzilmalar tasvirlangan texnologiya cheklangan hajmi diffuziya tomonidan olingan. Diffuziya qatlami $(\text{Si}_2)_{1-x}(\text{ZnSe})_x$ KEF-100 markali kremniyga asoslangan boʻlib, (111) kristallografik yoʻnalishi va 20 mm diametri bilan olingan. Kremniy asosidagi qatlamlar 5 mm qalinligi bilan