УДК 16+11+17+51-7+512+510.687+510.82+531.62

DOI: 10.17506/18179568_2021_18_2_142

# ЛОГИЧЕСКИ ФОРМАЛИЗОВАННАЯ АКСИОМАТИЧЕСКАЯ СИСТЕМА ЭПИСТЕМОЛОГИИ КСИ, МОДЕЛИРУЮЩАЯ ЭКСТРАОРДИНАРНОЕ УТВЕРЖДЕНИЕ КАНТА О ПРЕДПИСЫВАНИИ ФИЗИКОМ АПРИОРНЫХ ЗАКОНОВ ПРИРОДЕ

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*Статья поступила в редакцию 18.02.2021, принята к публикации 30.06.2021*

**Для цитирования:** Лобовиков В.О. Логически формализованная аксиоматическая система эпистемологии Кси, моделирующая экстраординарное утверждение Канта о предписывании физиком априорных законов природе // Научный журнал «Дискурс-Пи». 2021. Т. 18. № 2. С. 142–157. https://doi.org/10.17506/18179568_2021_18_2_142

Аннотация

Предмет исследования – приложение логики и дискретной математики к философии физики, а именно к учению Канта о *предписывании априорных законов природе*. Метод – конструирование и исследование дискретных математических моделей: *формальной аксиоматической теории знания*, именуемой Кси; *двузначной алгебраической системы метафизики* как формальной аксиологии. Научная новизна: впервые даются качественно новые (а именно *формально-аксиологические*) интерпретация, уточнение, объяснение и оправдание странной идеи Канта о *предписании* физиком *априорных законов природе*. Упомянутая до сих пор неизвестная дискретная математическая модель предписывания априорных законов природе рассматривается на примере закона сохранения энергии. Согласно обсуждаемой идее Канта, если некто *a-priori* знает закон сохранения энергии, то этот некто *предписывает* данный закон природе, которая *должна* ему подчиняться. В системе *эмпирического* знания «есть» и «предписано (должно быть)» логически разделены «Гильотиной Юма». Если этот принцип логического разделения абсолютно универсален, то утверждение Канта, что «*понимание предписывает априорные законы природе*», является ложным. Вопреки такому выводу, с помощью формальной аксиоматической теории Кси и двузначной алгебраической системы метафизики как формальной аксиологии в данной статье *дедуктивно доказывается*, что идея Канта о *предписывании* физиком *априорных законов природе* совершенно адекватна. Это *дедуктивное доказательство* неожиданно и нетривиально; оно означает, что сфера применимости «Гильотины Юма» является не универсальной, а ограниченной; такой ограничивающий результат – важная инновация. Это вызов доминирующей парадигме, что, в *логически непротиворечивой* теории Кси, *формально доказуема* такая схема формул, которая означает логическую эквивалентность модальности «необходимо» и модальности «обязательно (предписано)» при условии, что знание является априорным. Будучи формально доказана в Кси, упомянутая схема формул является математической моделью и оправданием обсуждаемой загадочной идеи Канта.

Ключевые слова:

мультимодальная логика, алгебра метафизики, формально-аксиологический закон, формальная аксиоматическая теория, эпистемология, априорное знание, эмпирическое знание, философские основания физики, идея Канта о предписывании априорных законов природе, закон сохранения энергии.

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DOI: 10.17506/18179568_2021_18_2_142

# A LOGICALLY FORMALIZED AXIOMATIC EPISTEMOLOGY SYSTEM KSI MODELING KANT'S EXTRAORDINARY STATEMENT OF PHYSICIST'S PRESCRIBING A-PRIORI LAWS TO NATURE

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*Article received on February 18, 2021, accepted on June 30, 2021*

**For citation:** Lobovikov, V.O. (2021). A Logically Formalized Axiomatic Epistemology System Ksi Modeling Kant's Extraordinary Statement of Physicist's Prescribing A-Priori Laws to Nature. *Scientific journal "Discourse-P"*, *18*(2), 142–157. https://doi.org/10.17506/18179568_2021_18_2_142

Abstract

The subject-matter – applying logic and discrete mathematics to philosophy of physics, namely, to Kant's conception of *prescribing a-priori laws to nature*. Method – constructing and investigating discrete mathematical models: a *formal axiomatic theory-of-knowledge* called "Ksi"; a two-valued *algebraic system of metaphysics* as formal axiology. Scientific novelty: for the first time, qualitatively new (namely, *formal-axiological*) interpretation, explication, explanation, and vindication are given for Kant's odd idea of physicist *prescribing a-priori laws to nature*. The hitherto unknown discrete mathematical model of prescribing a-priori laws to nature is exemplified by the law of conservation of energy. According to Kant's idea in question, if one *a-priori* knows the energy-conservation-law, then the one *prescribes* the law to nature which *must* obey the law. In *empirical*-knowledge system *"is" and "is prescribed (must be)" are logically separated* by "Hume-Guillotine". If this logical-separation principle is absolutely universal, then Kant's affirming that "*the understanding prescribes a priori laws to nature*" is wrong. Notwithstanding this conclusion, by means of the formal-axiomatic-theory Ksi and the two-valued algebraic system of metaphysics-as-formal-axiology, this article *proves deductively* that Kant's idea of physicist's *prescribing a-priori-laws-to-nature* is perfectly adequate. This *deductive proof* is surprising and nontrivial; it means that applicability domain of "Hume-Guillotine" is not universal but limited; such limiting-result is an important innovation. It is a challenge for the dominating paradigm that, in the *consistent* theory Ksi, such a formula-scheme is *formally provable* which means logical equivalence of modality "necessary" and modality "obligatory (prescribed)" under the condition that knowledge is *a-priori* one. Being formally proved in Ksi the wonderful formula-scheme is a mathematical model and vindication of Kant's enigmatic idea.

Keywords:

multimodal-logic, algebra-of-metaphysics, formal-axiology-law, formal-axiomatic-theory, epistemology, a-priori-knowledge, empirical-knowledge, philosophical-grounds-of-physics, Kant's-idea-of-prescribing-a-priori-laws-to-nature, law-of-conservation-of-energy.

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> "It has hitherto been assumed that our cognition must conform to the objects; but all attempts to ascertain anything about these objects *a priori*, by means of conceptions, and thus to extend the range of our knowledge, have been rendered abortive by this assumption. Let us then make an experiment whether we may not be more successful in metaphysics, if we assume that the objects must conform to our cognition" (Kant, 1994, p. 7).

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"Even the main proposition that has been elaborated throughout this entire part, already leads by itself to the proposition: that the highest legislation for nature must lie in our self, i.e., in our understanding, and that we must not seek the universal laws of nature from nature by means of experience, but, conversely, must seek nature, as regards its universal conformity to law, solely in the conditions of the possibility of experience that lie in our sensibility and understanding; …" (Kant, 2004, p. 71).

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"We must, however, distinguish empirical laws of nature, which always presuppose particular perceptions, from the pure or universal laws of nature, which, without having particular perceptions underlying them, contain merely the conditions for the necessary unification of such perceptions in one experience; with respect to the latter laws, nature and possible experience are one and the same, and since in possible experience the lawfulness rests on the necessary connection of appearances in one experience (without which we would not be able to cognize any object of the sensible world at all), and soon the original laws of the understanding, then, even though it sounds strange at first, it is nonetheless certain, if I say with respect to the universal laws of nature: *the understanding does not draw its (a priori) laws from nature, but prescribes them to it*" (Kant, 2004, pp. 71–72).

**Introduction**

The above-placed quite representative citations from I. Kant's writings introduce philosophical (epistemological) contents of the nontrivial problem to be an object of applying discrete mathematics in this article. In my opinion, today the problem under consideration is suspended in a deadlock. I think that to jump out from the deadlock and to succeed in solving the problem it is relevant to utilize the conceptual apparatus and methods of contemporary logic and discrete mathematics. I guess that applying discrete mathematics to philosophical grounding physics is an effective means for successful solving the problem which is heavy one. Being formulated and discussed by philosophers in the ambiguous natural language exclusively, the indicated nontrivial problem formulation is too knotty; it is not quite clear. Hence, to apply the machinery of discrete mathematics to this problem successfully, first of all, it is necessary to translate the problem formulation from the natural language to an artificial language of mathematical model of this problem. This translating into the artificial language starts from the next paragraph of the present paper. However, below in the introduction it is worth giving a short formulation of the problem in natural language.

As a rule, the physicists who deal exclusively with experiments, facts and measurements, believe not in physicist mind's prescribing laws to nature but in nature's prescribing laws to physicist's mind. Usually, the contrary position is evaluated by the physicists as a vulgar (or "subjective") idealism which is labeled by them as utterly not sound philosophical worldview incompatible with proper science of nature. I. Kant used to criticize the vulgar (or "psychological") idealism as well (Kant, 1994, 1996). Nevertheless, he insisted that physicist's understanding prescribes pure *a-priori* laws to nature (Kant, 1994, 1996, 2004). Some people think that this makes a significant discrepancy (even inconsistency) in Kant's philosophy of physics. Below in the present article, at the level of a discrete mathematical model, I am to demonstrate that the impression of Kant's self-contradiction is an illusion naturally arising from complete identifying notions: "knowledge (in general)", "*a-priori*-knowledge", and "*a-posteriori*-knowledge". Such identifying is a blunder to be eliminated. However, being psychologically camouflaged the blunder is committed by negligence very often. Therefore, in first approximation, Kant's extraordinary idea of physicist's prescribing *a-priori* laws to nature seems somewhat paradoxical and enigmatic. The puzzling idea has attracted special attention by respectable researchers: (Massimi, 2014a, 2014b; Massimi & Breitenbach, 2017; Pollok, 2014; Watkins, 2014). In complement to these publications systematically studying Kant's works (written in natural language) by methods of history of philosophy, below in this paper for the first time in philosophy of physics and in Kantian studies, a *formal-axiological* interpretation, explication, and reconstruction of Kant's enigmatic idea is undertaken by means of a formal axiomatic epistemology theory Ξ (Ksi) formulated in an unambiguous artificial language.

In the logically formalized axiomatic theory Ξ, the formula-scheme (Aα ⊃ (□ω ↔ Oω)) is a scheme of theorems. Here: symbols α and ω stand for any formulae of Ξ; Aα stands for "physicist *a-priori* knows that α"; □ω stands for "it is *necessary* that ω", and Oω stands for "it is *commanded, prescribed, obligatory* that ω". The modality □ω represents a law of nature. The modality Oω represents "physicist's command, *prescription*, making obligatory that ω". The theorem-scheme (Aα ⊃ (□ω ↔ Oω)) formally proved (within Ξ) below in this article is considered as a discrete mathematical model of/for the enigmatic statement by Kant. The mentioned formal axiomatic epistemology theory synthesizing consistently the three different notions: "knowledge (in general)"; "*a-priori* knowledge"; and "*empirical* knowledge", is defined as follows.

## 1. A precise definition of Ξ

The paragraph 2 of this paper is aimed at making the reader acquainted with the rigorous formulation of Ξ originally given in (Lobovikov, 2018b, 2018c). The formal axiomatic epistemology theory Ξ is a result of developing the axiomatic epistemology system suggested in (Lobovikov, 2016a, 2016b).

According to the definition, the logically formalized axiomatic epistemology system Ξ contains all symbols (of the alphabet), expressions, formulae, axioms, and inference-rules of the classical propositional logic. Symbols q, p, d, … (called propositional letters) are *elementary* formulae of Ξ. Symbols α, ω, π, β, … (belonging to meta-language) stand for any formulae of Ξ. In general, the notion "formulae of Ξ" is defined as follows.

1) All propositional letters q, p, d, … are formulae of Ξ.
2) If α and ω are formulae of Ξ, then all such expressions of the object-language of Ξ, which possess logic forms ¬α, (α ⊃ ω), (α ↔ ω), (α & ω), (α ∨ ω), are formulae of Ξ as well. (Here ¬, ⊃, ↔, &, ∨ are called "negation", "material implication", "equivalence", "conjunction", "not-excluding disjunction", respectively.)

3) If $\alpha$ is a formula of $\Xi$, then $\Psi\alpha$ is a formula of $\Xi$ as well.
4) Successions of symbols (belonging to the alphabet of the object-language of $\Xi$) are formulae of $\Xi$, only if this is so owing to the above-given items 1) – 3) of the present definition.

The symbol $\Psi$ belonging to meta-language stands for any element of the set of modalities {$\Box$, K, A, E, S, T, F, P, Z, G, O, B, U, Y}. Symbol $\Box$ stands for the alethic modality "necessary". Symbols K, A, E, S, T, F, P, Z, respectively, stand for modalities "agent *knows* that…", "agent *a-priori knows* that…", "agent *a-posteriori knows* that…", "under some conditions in some space-and-time a person (immediately or by means of some tools) *sensually perceives* (has *sensual verification*) that…", "it is *true* that…", "person *believes* that…", "it is *provable* that…", "there is *an algorithm* (a machine could be constructed) *for deciding* that…".

Symbols G, O, B, U, Y, respectively, stand for modalities "it is *(morally) good* that…", "it is *obligatory* that …", "it is *beautiful* that …", "it is *useful* that …", "it is *pleasant* that …". Meanings of the mentioned symbols are defined by the following schemes of own-axioms of proper philosophical epistemology system $\Xi$ which own-axioms are added to the axioms of classical propositional logic. Schemes of axioms and inference rules of the classical propositional logic are applicable to all formulae of $\Xi$ (including the ones constructed by the item 3 of the definition).

Axiom scheme AX-1: $A\alpha \supset (\Box\omega \supset \omega)$.

Axiom scheme AX-2: $A\alpha \supset (\Box(\omega \supset \beta) \supset (\Box\omega \supset \Box\beta))$.

Axiom scheme AX-3: $A\alpha \leftrightarrow (K\alpha \,\&\, (\Box\alpha \,\&\, \Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega)))$.

Axiom scheme AX-4: $E\alpha \leftrightarrow (K\alpha \,\&\, (\neg\Box\alpha \vee \neg\Box\neg S\alpha \vee \neg\Box(\omega \leftrightarrow \Omega\omega)))$.

In AX-3 and AX-4, the symbol $\Omega$ (belonging to the meta-language) stands for any element of the set $\Re$ = {$\Box$, K, T, F, P, Z, G, O, B, U, Y}. Let elements of $\Re$ be called "*perfection*-modalities" or simply "perfections".

A proof of logic consistency of $\Xi$ has been submitted originally in (Lobovikov, 2018c).

## 2. Formal proofs (in $\Xi$) of such philosophically interesting theorem-schemes which are directly relevant to Kant's statement in question

Strictly speaking, here I mean not proofs of theorems but schemes of proofs of schemes of theorems. They are the following.

### 2.1. A theorem-scheme $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$

For any $\Sigma$ and $\Omega$, it is provable in $\Xi$ that $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$, where the symbols $\Sigma$ and $\Omega$ (belonging to the meta-language) stand for any elements of the set $\Re$ = {$\Box$, K, T, F, P, Z, G, O, B, U, Y}. The following succession of schemes of formulae is a scheme of proofs of/for $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$ in $\Xi$.

1) $A\alpha \leftrightarrow (K\alpha \,\&\, (\Box\alpha \,\&\, \Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega)))$: axiom scheme AX-3.
2) $A\alpha \supset (K\alpha \,\&\, (\Box\alpha \,\&\, \Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega)))$: from 1 by the rule of elimination of $\leftrightarrow$.
3) $A\alpha$: assumption.
4) $(K\alpha \,\&\, (\Box\alpha \,\&\, \Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega)))$: from 2 and 3 by *modus ponens*.

5) $\Box(\omega \leftrightarrow \Omega\omega)$: from 4 by the rule of elimination of &.
6) $(\omega \leftrightarrow \Omega\omega)$: from 5 by the rule[1] of elimination of $\Box$.
7) $(\omega \leftrightarrow \Sigma\omega)$: from 6 by substituting $\Sigma$ for $\Omega$.
8) $(\Sigma\omega \leftrightarrow \omega)$: from 7 by commutativity of $\leftrightarrow$.
9) $(\Sigma\omega \leftrightarrow \Omega\omega)$: from 8 and 6 by transitivity of $\leftrightarrow$.
10) $A\alpha \vdash (\Sigma\omega \leftrightarrow \Omega\omega)$: by 1–9. (In this paper the symbol "… |—…" stands for "from… it is logically derivable that…".)
11) $\vdash A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega)$: from 10 by the rule of introduction of $\supset$.

Here you are.

### 2.2. Theorem-schemes $(A\alpha \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$, $(A\alpha \supset \Box\Omega\alpha)$, and $(A\alpha \supset \Omega\alpha)$

It is relevant to mention here that the following finite succession of formula-schemes is a formal proof (in $\Xi$) of the philosophically interesting theorem-scheme $(A\alpha \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$, where $\Omega$ takes values from the set $\Re$.

1) $A\alpha \leftrightarrow (K\alpha \,\&\, (\Box\alpha \,\&\, \Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega))$: axiom scheme AX-3.
2) $A\alpha \supset (K\alpha \,\&\, (\Box\alpha \,\&\, \Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega))$: from 1 by the rule of elimination of $\leftrightarrow$.
3) $A\alpha$: assumption.
4) $K\alpha \,\&\, \Box\alpha \,\&\, \neg\Box\neg S\alpha \,\&\, \Box(\omega \leftrightarrow \Omega\omega)$: from 2 and 3 by *modus ponens*.
5) $\Box(\omega \leftrightarrow \Omega\omega)$: from 4 by the rule of &-elimination.
6) $A\alpha \supset (\Box(\omega \leftrightarrow \beta) \supset (\Box\omega \leftrightarrow \Box\beta))$: theorem scheme.
7) $A\alpha \supset (\Box(\omega \leftrightarrow \Omega\omega) \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$: from 6 by substituting $\Omega\omega$ for $\beta$.
8) $\Box(\omega \leftrightarrow \Omega\omega) \supset (\Box\omega \leftrightarrow \Box\Omega\omega)$: from 7 and 3 by *modus ponens*.
9) $(\Box\omega \leftrightarrow \Box\Omega\omega)$: from 8 and 5 by *modus ponens*.
10) $A\alpha \vdash (\Box\omega \leftrightarrow \Box\Omega\omega)$: by 1–9.
11) $\vdash (A\alpha \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$: from 10 by the rule of introduction of $\supset$.

Here you are.

The following continuation of the previous succession of formulae-schemes is a proof of the formula-scheme $(A\alpha \supset \Box\Omega\alpha)$.

12) $\Box\alpha$: from 4 by the rule of &-elimination.
13) $(\Box\alpha \leftrightarrow \Box\Omega\alpha)$: from 9 by substituting $\alpha$ for $\omega$.
14) $(\Box\alpha \supset \Box\Omega\alpha)$: from 13 by elimination of $\leftrightarrow$.
15) $\Box\Omega\alpha$: from 12 and 14 by *modus ponens*.
16) $A\alpha \vdash \Box\Omega\alpha$: by 1–15.
17) $\vdash (A\alpha \supset \Box\Omega\alpha)$: from 16 by the rule of introduction of $\supset$.

Here you are.

Finally, by applying the (conditioned) rule of elimination of $\Box$ to 16) $A\alpha \vdash \Box\Omega\alpha$, it is proved that $A\alpha \vdash \Omega\alpha$. Consequently, $\vdash (A\alpha \supset \Omega\alpha)$.

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[1] This conditioned (limited) rule is formulated as follows: $A\alpha, \Box\omega \vdash \omega$. The mentioned rule is not included into the above-given definition of $\Xi$, but it is easily *derivable* in $\Xi$ by means of the axiom scheme AX-1 and *modus ponens*. The rule $\Box\omega \vdash \omega$ is not derivable in $\Xi$, and also Gödel's necessitation rule is not derivable in $\Xi$. Nevertheless, a limited (conditioned) necessitation rule is derivable in $\Xi$, namely, $A\alpha, \omega \vdash \Box\omega$.

### 2.3. Philosophical interpretation and discussion of the above-proved theorems in relation to Kant's extraordinary statement that physicist's understanding prescribes *a-priori* laws to nature

From the viewpoint of purely mathematical technique, the formal proofs of $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$, $(A\alpha \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$, $(A\alpha \supset \Box\Omega\alpha)$, and $(A\alpha \supset \Omega\alpha)$ in $\Xi$ are not interesting (too simple). But from the viewpoint of proper philosophy contents, they are very interesting and important. Various concrete philosophical interpretations (particular cases) of these statements are well-known as fundamental philosophical principles of the rationalism (a-priori-ism). Representative examples of the specific philosophical principles are given in (Lobovikov, 2016a, 2017b, 2018a). A long list of different concrete philosophical interpretations of formulae-schemes $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$, $(A\alpha \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$ has been submitted in (Lobovikov, 2018c).

In particular, the following specific philosophical interpretations of the theorem-scheme $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$ are immediately connected with Kant's odd idea under consideration.

a) $A\alpha \supset (\Box\omega \leftrightarrow O\omega)$: this is obtained from $(A\alpha \supset (\Sigma\omega \leftrightarrow \Omega\omega))$ by substituting: $\Box$ for $\Sigma$; and $O$ for $\Omega$. The theorem-scheme models the nontrivial philosophical principle of interconnection of corresponding *alethic* and *deontic* modalities, which principle has been manifestly expressed for the first time by (Leibniz, 1971, p. 466, 481). However, concealed prerequisits of this principle exist even in works by Aristotle (1994a).

b) $A\alpha \supset (\Box\omega \leftrightarrow G\omega)$: this theorem-scheme (obtained by substituting: $\Box$ for $\Sigma$; and $G$ for $\Omega$) represents the rationalistic principle of equivalence between necessary being and goodness. Initially the principle was expressed by some outstanding creators of Ancient-Roman-Law, for example, Ulpian, some great theologians, for example, T. Aquinas (1994a, 1994b), and some great representatives of rationalism philosophy, for instance, B. Spinoza (1994) and G.W. Leibniz (1903, 1952, 1971, 1996).

c) $A\alpha \supset (G\omega \leftrightarrow O\omega)$: this surprising statement follows logically from a) and b).

In its turn, the above-proved theorem-scheme $(A\alpha \supset (\Box\omega \leftrightarrow \Box\Omega\omega))$ may be instantiated by the following nontrivial philosophical principles directly connected with the present paper theme.

i. $A\alpha \supset (\Box\omega \leftrightarrow \Box G\omega)$: the *a-priori* natural-law principle of *equivalence of necessary being and necessary goodness*, represented in (Aristotle, 1994a, 1994b), and (Aquinas, 1994a, 1994b). In the Roman Law this principle was used by Ulpian.

ii. $A\alpha \supset (\Box\omega \leftrightarrow \Box O\omega)$: the *a-priori* natural-law principle of *equivalence of necessary being and necessary norm (duty)*, represented, for instance, in works by Cicero, I. Kant, and H. Kelsen.

From (i) and (ii), it follows logically that $A\alpha \supset (\Box O\omega \leftrightarrow \Box G\omega)$: the *a-priori* principle of equivalence of the *normative* (deontic) and the *evaluative* options of formulating the natural-law doctrine.

In my opinion, the above-mentioned set of principles (deductively proved above in the axiomatic theory $\Xi$) is an adequate model of/for Kant's genius idea of physicist's *prescribing a-priori laws to nature*.

### 3. A hitherto not recognized formal-axiological aspect of the law of conservation of energy as an instantiation of corollaries following logically from the above-proved theorem-schemes

Suppose that absolutely-universal-and-necessarily-necessary *a-priori* laws of nature do exist. What follows logically from this assumption in the theory Ξ? With respect to Kant's philosophy of physics this question is very interesting. However, the above supposition of existence is not constructive. For its constructiveness it is necessary to give at least one concrete example of such laws. Therefore, let us assume that the great law of conservation of energy is an absolutely-universal-and-necessarily-necessary *a-priori* law of physics. Obviously, this assuming is risky, but let us risk to accept the hypothesis (at least temporarily) for systematical investigating its consequences (being psychologically ready to abandon the hypothesis at any moment). In other words, let us exploit the famous hypothetic-deductive method. Let the symbol ¤ stand for the *concrete* proposition of physics "in any closed system, finite quantity of its energy does not change". Owing to the hypothetic-deductive method, within Ξ, from the three-element set {the hypothetical premise □¤, the assumption A¤, and the theorem (A¤ ⊃ (□¤ ↔ □G¤)) obtained from the theorem-scheme (i) Aα ⊃ (□ω ↔ □Gω) by substituting: ¤ for α; and ¤ for ω} it is formally derivable that □G¤. This is a surprise and even an astonishment for the positivist-minded scientists equipped with dogmatic (not-revisable) belief in absolute universality of the domain of relevant applicability of the *anti-axiology* paradigm in general: (Carnap, 1931; Mach, 1914, 2006; Russel, 1914, 1948, 1956, 1986, 1992; Schlick, 1974, 1979a, 1979b) and in absolute universality of the well-known particular doctrine of "naturalistic fallacies in ethics" by G.E. Moore (2004), especially. Owing to the hypothetic-deductive method, within Ξ, one can rigorously demonstrate that the domain of applicability of Moore's doctrine is limited (Lobovikov, 2017b). Soundness of absolute separation between statements of being and corresponding ones of value is not absolutely universal: under a perfectly definite extraordinary condition (namely, under the assumption that Aα) an affirmation of *necessary being* is equivalent to corresponding affirmation of *necessary goodness*.

Can it be so that *necessary being* of conservation of energy in a closed system is *necessarily good*? Let us undertake systematical investigating this nontrivial question. Firstly, let us try to construct such a formal-axiology system in which the notion "necessarily good" is defined precisely and an effective method (algorithm) exists for deciding whether something is necessarily good or not. To do this let us define a two-valued algebra of formal axiology (Lobovikov, 2014, 2016d). I had created this algebra at the very beginning of 70th of XX century, but due to the ideological circumstances in the USSR (Marxism-Leninism fight with formalism in philosophy, science and fine arts), it was published only at the very beginning of 80th of XX century. A list of the first publications on two-valued algebra of formal axiology can be found in (Lobovikov, 1999).

Algebra under consideration is based upon the set Δ of any such (and only such) either existing or not-existing things, or processes, or persons (individual or collective ones – it does not matter), which are either good, or bad ones (from the viewpoint of an evaluator). Algebraic operations defined on the set Δ are abstract-evaluation-functions (in particular, moral-value-ones). Abstract-evaluation-variables of these functions take their values from the set *{g, b}*. Here the symbols "*g*" and "*b*" stand for the abstract positive values "good" and "bad", respectively. The functions take their values from the same set. The symbols: "*x*" and "*y*" stand for axiological-forms of elements of Δ. Elementary axiological-forms deprived of their contents are independent abstract-evaluation-arguments. Compound axiological-forms deprived of their contents are abstract-evaluation-functions determined by these arguments.

Let symbol Σ stand for the *evaluator*, i. e. for that person (individual or collective one – it does not matter), in relation to which all evaluations are generated. In the abstract-evaluation-relativity theory, Σ is a variable: changing values of the variable Σ can result in changing evaluations of concrete elements of Δ. However, if a value of the variable Σ is fixed, then evaluations of concrete elements of Δ are definite.

Speaking of abstract-evaluation-functions in this paper I mean the following mappings (in the proper mathematical meaning of the word "mapping"): {g, b} → {g, b}, if one speaks of the functions determined by *one* variable; {g, b}×{g, b} → {g, b}, where "×" stands for the Cartesian multiplication of sets, if one speaks of the functions determined by *two* variables; $\{g, b\}^N \rightarrow \{g, b\}$, if one speaks of the functions determined by N variables, where N is a finite positive integer. Below tabular definitions are given of/for some elementary evaluation-functions immediately related to the contents of this article.

The *glossary* for the below evaluation-table 1: Let the symbol *Bx* stand for the evaluation-function "*being (existence) of* (what, whom) *x*". *Nx* stands for the evaluation-function "*non-being (nonexistence) of* (what, whom) *x*". *Mx* – "*movement of* (what, whom) *x*". *Fx* – "*finite* (what, who) *x*". *Jx* – "*possibility of x*". *Ex* – "*energy of x*". *Qx* – "*quantity (magnitude) of x*". *Cx* – "*conservation of x, i. e. x's being constant, immutable*". *Dx* – "*closedness, protected-ness of x, i. e. x's being closed, isolated, independent, protected from any outside action*". The introduced functions are defined by the following table 1.

Table 1 – The Unary Evaluation-Functions

| *x* | *Bx* | *Nx* | *Mx* | *Fx* | *Jx* | *Ex* | *Qx* | *Cx* | *Dx* |
|---|---|---|---|---|---|---|---|---|---|
| g | g | b | b | b | g | b | g | g | g |
| b | b | g | g | g | b | g | b | b | b |

Below in the table 2 defining the binary evaluation-functions, the symbol $K^2xy$ stands for "*conjoining, uniting x* and *y* in a whole"; the symbol $E^2xy$ – "*equating, equalizing* (identifying the values of) *x* and *y*"; $W^2xy$ – "*y*'s *war*, fight, struggle with *x*". The symbol $A^2xy$ – "*y*'s *action* (aggression, assault, attack, offensive) on *x*". $T^2xy$ – "*y*'s *termination*, annihilation, destruction of (what, whom) *x*". $C^2xy$ – "*conservation*, preservation, protection, defense of (what, whom) *x* by (what, whom) *y*". (In the table 2 and hear-after in this paper the upper index 2 informs that the indexed capital letter stands for a *binary* evaluation-function.)

Table 2 – The Binary Functions

| *x* | *y* | $K^2xy$ | $E^2xy$ | $W^2xy$ | $A^2xy$ | $T^2xy$ | $C^2xy$ |
|---|---|---|---|---|---|---|---|
| g | g | g | g | b | b | b | g |
| g | b | b | b | b | b | b | g |
| b | g | b | b | g | g | g | b |
| b | b | b | g | b | b | b | g |

Definition 1 (of *formal-axiological-equivalence*-relation): in two-valued algebraic system of formal *axiology*, abstract-evaluation-functions (pure evaluation-forms) *Ω* and *Ψ* are *formally-axiologically equivalent* (this is represented by the symbol "*Ψ*=+=*Ω*"), if and only if they acquire identical axiological values (from the set {*g (good)*, *b (bad)*}) under any possible combination of the values of their abstract-evaluation-variables.

Definition 2 (of *formal-axiological law*): in two-valued algebra of formal *axiology*, any abstract-evaluation-function *Ψ* is called *formally-axiologically (or invariantly) good* one (or a *law* of algebra of formal *axiology*), if and only if it acquires the value *g (good)* under any possible combination of the values of its variables. In other words, the function *Ψ* is *formally-axiologically (or constantly) good* one, iff *Ψ*=+=*g (good)*.

By using the above-given definitions and computing relevant evaluation-tables it is easy to demonstrate the following equations of algebra of formal-axiology.

1) Ex=+=JMx. (This equation could be used as a definition of Ex.)

2) Dx=+=CFQEx.

3) $E^2$DxCFQEx=+=g.

The formal-axiological equivalences 2) and 3) represent the *formal-axiological law* of conservation of energy, which law is a *formal-axiological analog* of the corresponding necessarily universal law of physics. (Originally, the *formal-axiological law* of conservation of energy was published in (Lobovikov, 2012a, 2012b, 2015a). Now let us depart from *formal-axiology* to logic[2]. To do this let us define a function (called "realization-function") such that, for any evaluation-function Ψ, the symbol [Ψ] stands for either true or false *proposition* informing that Ψ is realized (exists in reality). Owing to the above-said, the following logic equivalences are to be accepted.

A. ¤ ↔ [$E^2$DxCFQEx].

B. G[$E^2$DxCFQEx] ↔ G¤.

According to the above formal-axiological equivalence 3) $E^2$DxCFQEx=+=g, demonstrated by computing the corresponding evaluation-table, it is true that G[$E^2$DxCFQEx], and *it cannot be otherwise*; consequently, it is *necessarily* true that G[$E^2$DxCFQEx]. Hence, it is true that G¤ and □G¤.

From G¤ and the theorem (A¤ ⊃ (G¤ ↔ O¤)), obtained from the theorem-scheme (Aα ⊃ (Gα ↔ Oα)) by substituting ¤ for α, it follows logically that (A¤ ⊃

[2] Although there is a heuristically important fundamental analogy between two-valued algebra of formal axiology and two-valued algebra of formal logic, strictly speaking in general, "formal axiology" and "formal logic" are not synonyms as "value (in general)" and "truth" are not synonyms, respectively.

O¤). Translating this corollary into the natural language is the following: if knowledge of the energy-conservation-law in physics is *a-priori* one then *the law is prescribed (commanded) to nature* by physicist cognizing nature. Thus, Kant's enigmatic statement under discussion is vindicated; it is justified in general (at the abstract theory level), and exemplified by the energy-conservation-law presumed as *a-priori* one.

Another option (more direct, and short one): in Ξ, from the two-element set {the assumption A¤, the theorem (A¤ ⊃ (□¤ ↔ O¤)) obtained from the theorem-scheme $(A\alpha \supset (\Box\alpha \leftrightarrow O\alpha))$ by substituting ¤ for α} it is formally derivable that O¤. The inference is very simple because (A¤ ⊃ □¤) is a theorem in Ξ.

Moreover, in Ξ, from the two-element set {the assumption A¤, the theorem (A¤ ⊃ □O¤) obtained from the above-proved theorem-scheme $(A\alpha \supset \Box\Omega\alpha)$ by substituting: ¤ for α; and O for Ω} it is formally derivable that □O¤ (by *modus ponens*). Thus, from the viewpoint of the discrete mathematical model under investigation, Kant is right: if physicist's knowledge of a law of nature is *a-priori* one then it is *necessary* that *the law is prescribed (commanded) to nature* by physicist understanding nature.

The simplest option of effective justifying Kant's enigmatic statement in question is the following. In Ξ the *universal* formulation of Kant's statement under discussion is proved by substituting O for Ω in the above-proved statement that $\vdash (A\alpha \supset \Omega\alpha)$. The *particular* case used above in Ξ (for instantiation by the concrete example from physics) is proved by substituting ¤ for α in the already proved statement that $\vdash (A\alpha \supset O\alpha)$.

**Conclusion**

Being a formally proved theorem-scheme in Ξ, the wonderful formula-scheme $(A\alpha \supset (\Box\omega \leftrightarrow O\omega))$ is considered in this paper as an adequate model of/for Kant's puzzling idea in question. The model has shown Kant's significant deviation from the extreme empiricism of J. Locke (1994) and D. Hume (1874, 1994) to Spinoza-Leibniz' rationalism and *a-priori*-ism in spite of Kant's being inclined to criticize Leibniz' rationalism metaphysics as a whole.

The theorem-scheme $(A\alpha \supset (\Box\omega \leftrightarrow O\omega))$, formally proved in Ξ, undermines absolute universality of domain of applicability of the well-known principle of logically unbridgeable gap between "is" and "is prescribed" (or "is obligatory") *conventionally* called "Guillotine of Hume" (Lobovikov, 2015b, 2016c, 2016d, 2018c). The indicated theorem-scheme limits (reduces) the Guillotine's applicability domain to the pure *empirical* knowledge system, i. e. to the totality of *facts* (*contingent* truths), exclusively. Thus, in some sense, in the present article the nontrivial problem of significant restricting and precise defining the scope of valid applicability of Hume-and-Moore doctrine of fact/value dichotomy is solved finally.

However, this paper does not completely exhaust the possibilities of fruitful scientific activity in the newly indicated direction. Still there are relevant themes for discussions and interesting theoretical problems waiting their solutions. I guess that further developing the research submitted in this article may be accomplished in two ways.

Firstly, in future it is worth thinking of a possibility of significant development of the formal axiomatic epistemology system Ξ. It has been shown in (Lobovikov, 2018c) that Ξ is consistent but what about its completeness? Still the question is open. Yet it is not quite clear whether the above-presented set of axiom-schemes of Ξ is sufficient for adequate mathematical modeling the application domain. At the present moment it is even not possible exactly to formulate the problem of completeness of Ξ because only the *syntax* of Ξ is elaborated sufficiently and represented manifestly. In future, an option of *formal-axiological semantics* of logically formalized axiomatic philosophical-epistemology-and-ontology system is to be elaborated and represented manifestly as well. I guess that some new axiom-schemes are to be added to Ξ. I believe that some of the additional axiom-schemes are to define precisely the *formal-axiological* aspect of universal philosophical epistemology and ontology. In a future hypothetical extension of Ξ, the formal philosophical ontology, the formal philosophical epistemology and formal axiology are to be synthesized.

Secondly, in future it is worth thinking of a possibility of applying two-valued algebra of formal axiology to some other instances of necessarily universal laws of nature, for example, to some other great laws of conservation in physics, or to the principles of thermodynamics. Such hypothetical application attempts could be theoretically interesting, although it is necessary to be psychologically ready to failures of some of hypothetical-deductive reasonings and intellectual experiments. Let us try and see. In any way, the above-submitted unusual application of contemporary modal logic and discrete mathematics to philosophical grounds of physics is worth discussing and developing further.

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