**A Defence of Falsificationism**
**against Feyerabend's Epistemological Anarchism**
**using the Example of**
**Galilei's Observations with the Telescope**

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## Directory

1.Introduction..... 3
2.Feyerabend's Epistemological Anarchism in Differentiation to Critical Rationalism.....4
2.1.Galilei's Utilisation of the Telescope and its Anarchistic Interpretation.....5
2.2.Feyerabend's Principle of Tenacity and the Thesis of Incommensurability.....7
3.A Falsificationist Interpretation of Observations with and without the Telescope .....8
4.Galilei's Observations en Détail..... 10
4.1.The Explanation of Venus' Phases..... 11
4.2.The Establishment of the Irradiation Hypothesis..... 13
4.3.The Moon and the Explanation of the Telescope's Functionality..... 14
4.4.Galilei's Incautious Defence of the Copernican Theory based on Reproducibility..15
5.A Rational Reconstruction of Galilei's Falsification of the Ptolemaic Theory.....16
6.Evaluation.....18
7.References..... 20

## 1. Introduction

In 1543, Nicolaus Copernicus' publication of his *De Revolutionibus Orbium Coelestium* began the Copernican revolution and contributed to the rise of the ensuing scientific revolution. The term “Copernican revolution” refers to the theory or paradigm shift away from the Ptolemaic model of the heavens towards the Copernican. The Ptolemaic model postulates the Earth at the centre of the galaxy (i.e. a geocentric model), whereas the Copernican one postulates the Sun at the centre (i.e. a heliocentric model). In 1610, Galileo Galilei provided support for the Copernican theory by observations with a telescope he had just constructed. Towards this end he observed *inter alias* the phases of the planet Venus. Based on these observations, Galilei published in 1632 a book which defends the heliocentric system. The English translation of the book is entitled *Dialogue Concerning the Two Chief World Systems*.[1]

Roughly 330 years later, Paul K. Feyerabend, a Western philosopher of science, examines the Copernican revolution in his book *Against Method: Outline of an Anarchistic Theory of Knowledge*. In this book Feyerabend takes the premise that Galileo's advancing of a heliocentric cosmology was an example of scientific progress. I agree on this premiss. He then tries to show that Galileo did not adhere to the conditions of critical rationalism. For this criticism of falsificationism he uses Galilei's observations with the telescope as a prime example. Feyerabend even argues that if Galileo had adhered to critical rationalism, then he could not have advanced a heliocentric cosmology. On this point I disagree with Feyerabend, and I want to show that this latter claim is false. The essay's aim is to examine, whether there is a tenable falsificationist reply to Feyerabend's criticism. I examine in particular, whether Galilei has defended the Copernican theory according to or at least compossible with critical rationalism. In consequence of the examination, one could even say that my project turns Feyerabend's own prime example against himself.

The structure of the argumentation is as follows: In chapter 2, I confront Feyerabend's position and critical rationalism in order to have a foundation or starting point for my (historical) investigation. The main difference of his position towards falsificationism is the belief that different theories cannot be discussed rationally. Feyerabend is convinced that Galilei's observations with the telescope in the historical context of the Copernican

[1] The German version of Galilei's book is entitled *Dialog über die beiden hauptsächlichen Weltsysteme: das Ptolemäische und das Kopernikanische*.

revolution supports his criticism. In particular, he argues that the Copernican theory was supported by deficient hypotheses, and falsifications were disposed by *ad hoc* hypotheses and propaganda. Furthermore, he claims that his philosophy of science reconstructs Galilei's defence of the Copernican theory. He introduces a central principle of his position, (the principle of tenacity) in order to justify a research strategy of not eliminating falsified theories. He tries to show that the tenacious defence of a theory corresponds to Galilei's defence of the Copernican theory. Remarkably, Feyerabend's approach to explain the development of science earns an important support from his interpretation of Galilei's observations.

In chapter 3, I give a falsificationist interpretation of Galilei's observations with the telescope, and oppose this interpretation to Feyerabend's. From a falsificationist perspective, auxiliary hypotheses compete during the Copernican revolution which can (with some effort) be critically discussed. In chapter 4, I analyse the historical case in order to test Feyerabend's interpretation of the Copernican revolution. *Inter alias* I investigate thoroughly whether Galilei, as Feyerabend claims, immunised falsifications of the Copernican theory by the introduction of *ad hoc* hypotheses. The investigation considers Galilei's explanation of Venus' phases, his establishment of the irradiation hypothesis, the explanation of the telescope's functionality, and the role of the reproducibility of the observations with the telescope. In chapter 5, I finally provide a rational reconstruction of Galilei's falsification of the Ptolemaic theory. The formalisation shows that Galilei was not a cautious critical rationalist, but a very confident scientist using the method of falsification.

## 2. Feyerabend's Epistemological Anarchism in Differentiation to Critical Rationalism

Paul Feyerabend is considered to be a representative of the “new philosophy of science”. As the other representatives of this movement, he criticised the positivistic or logically empiricist philosophy of science. However, his criticism concerns besides logical empiricism also Sir Karl Popper's methodology. He reproaches the founder of critical rationalism for the ambition to perceive science as rational. According to Feyerabend this

is untenable. He refers to the ambition of critical rationalists as “ratiomania”, which means immoderate preference for rationality, not to say pathological passion therefor.

In 1970, Feyerabend calls his position epistemological anarchism.[2] He regards science as fallible and experience as theory-dependent. So far his views are in agreement with critical rationalism. In contradistinction to it, Feyerabend does not think that a critical and rational discussion of competing theories is possible; for the theory-dependence of experience makes competing theories incommensurable. Since he thinks that theories are incommensurable, there is no common basis for such (actually desirable) critical discussions, and thus theories have to be discussed in an anarchistic way by using rhetoric and propaganda. In order to show this concretely Feyerabend picks out of the history of science an example: Galileo's defence of the Copernican theory.

Feyerabend tries to show that Galileo defended the Copernican theory (*CT*) according to his epistemological anarchism. In the time of Galileo, some phenomena were observable by the naked eye which were problematic for the *CT*, for instance the brightness and size variations of planets. Feyerabend claims that Galileo immunised these apparent falsifications by introducing an *ad hoc* hypothesis, namely that the telescope is reliable. In other words, Galileo's assumption of the telescope's reliability shows that he did not mind falsifications or removed them by immunising auxiliary hypotheses.

### 2.1. Galilei's Utilisation of the Telescope and its Anarchistic Interpretation

Before the telescope was invented, observations with the naked eye had been conducted which presumably falsified the *CT*. The theories of Copernicus and Ptolemy assume that the distances between the Earth and the planets vary. With your own eyes you can see brightness and size variations of the planets; but these variations are way to small as you can expect on the ground of what *both* theories predict. Galileo paid attention to the problem of the planet's variations concerning brightness and apparent size. According to him, Copernicus says nothing about the almost unvarying size of Venus when observed by the naked eye.[3]

[2] Cf. Feyerabend, P. K., *Against Method: Outline of an Anarchistic Theory of Knowledge*, 1st edition.
[3] Cf. Galilei, G., *Dialog über die beiden hauptsächlichen Weltsysteme: das Ptolemäische und das Kopernikanische*, p. 349.

When Galileo observed the planets with his telescope, which was a new instrument back then, he made remarkable discoveries. Equipped with his telescope, he was able to observe the planets' variations more precisely than with the mere eye. His observations of the planets' brightness and size variations *via* telescope were in accordance with the values predicted by Copernicus. According to Feyerabend this accordance proved for Galileo the truth of the *CT* and the usefulness of the telescope.[4]

Feyerabend adds that the auxiliary hypothesis of the telescope's reliability ($AH_1$) had been very insecure at the beginning: Galileo's first observations of the Moon *via* telescope were problematic; for his first maps of the Moon weren't right after his observations with the telescope. The values, obtained by the different modes of observation, differed for the planets' brightness and size variations. If observations with the naked eye contradict observations with the telescope, why should we assume that observations by telescope are reliable? What could Galileo oppose to the theory of his antagonists (influenced by Aristoteles' theory) that exclusively the naked eye is reliable and the telescope distorts?[5]

Feyerabend argues further that the *CT* was supported by deficient auxiliary hypotheses (e.g. $AH_1$), and refutations were disposed by *ad hoc* hypotheses and artful propaganda.[6] Such irrational methods of support had been necessary according to him because of the "unbalanced development" of the *CT* and its auxiliary hypotheses: $AH_1$ was necessary for the (back then) new *CT*, however, $AH_1$ was developed after the construction of the *CT*. He wants to express that the new theory with the old auxiliary hypotheses (for instance the assumption of the reliability of observations with the naked eye) could be falsified. Feyerabend perceives such later-introduced auxiliary hypotheses as *ad hoc* hypotheses.[7]

In summary, Feyerabend aims to show that Galileo's observations *via* telescope contradict observations with the naked eye, for instance, the observations of Venus' brightness and size variations. He interprets this as evidence for the claim that Galileo defended $AH_1$ according to his epistemological anarchism (more precisely: according to his principle of tenacity), and that Galileo ignored problems and even falsifications.

[4] Cf. Feyerabend, P. K., *Wider den Methodenzwang*, 2nd edition, p. 185. Feyerabend mentions only Mars' size variations, Galilei in his *Dialog* on p. 350 also the size variations of Venus.
[5] Cf. Feyerabend, *Wider den Methodenzwang*, pp. 128-68.
[6] Cf. Feyerabend, *Wider den Methodenzwang*, p. 187.
[7] Cf. ibid., pp. 188-202.

### 2.2. Feyerabend's Principle of Tenacity and the Thesis of Incommensurability

Feyerabend suggests a principle of tenacity according to which scientists should stick more or less dogmatically to theories in spite of considerable difficulties. First and foremost, such difficulties would be falsifications, as he argues in his historical case studies. He introduces this principle in order to justify a research strategy of not eliminating falsified theories: "Having adopted tenacity we can no longer use recalcitrant facts for removing a theory […] even if the facts should happen to be as plain and straight-forward as daylight itself".[8]

Feyerabend thinks that the principle of tenacity is rational, because theories can be developed and improved, test statements can be rejected, and (problematic) auxiliary hypotheses changed. By modifying and developing a theory you might improve it so much that earlier problems are solved. Observational and experimental errors are possible, and it takes time to get uniform experimental results. Explicit auxiliary hypotheses are used in order to derive test statements; implicit auxiliary hypotheses are used in order to decide what test statements to accept and what concepts to use in order to describe observations.

Feyerabend tries to show that the tenacious defence of a theory can be rational. For this aim he uses historical cases, for instance Galileo's defence of the Copernican theory. He thinks that these examples indicate that research in *our* world according to the falsificationist methodology meets insurmountable difficulties. For instance, the Ptolemaic and the Copernican theory were falsified by observations with the mere eye. In this world, the method of falsification would annihilate science. However, even though most theories are falsified, it is nevertheless rational according to the principle of tenacity to continue to work on them and to develop them. In this way Feyerabend tries to show that falsificationism is a methodology that is (logically) *possible* but cannot be used in actual research.[9]

Moreover, Feyerabend holds as mentioned before the thesis of incommensurability, that is, he does not believe that a theory can be criticised with theory-independent experience. The incommensurability of theories would not fully exclude the possibility of falsification, because incommensurable theories could be falsified by using their own kind of experience. Without a commensurable alternative, however, these refutations are quite

[8] Feyerabend, *Against Method: Outline of an Anarchistic Theory of Knowledge*, p. 205.
[9] Cf. Feyerabend, P. K., *Science in a Free Society*, p. 227.

weak. It is impossible to compare the empirical contents of theories except within the confines of a particular theory. Hence, Popper's methods for showing that there is progress in science cannot be used. The method of refutation, which can be used, is very much reduced in strength. “What remains are aesthetic judgements, judgements of taste, and our own subjective wishes.”[10]

As aforementioned, Feyerabend is convinced that actually desirable criticism and theory change can only be achieved by anarchistic means. According to him criticism of a theory requires another theory. On this background, the pluralism of theories in epistemological anarchism has another significance than to critical rationalists which regard this pluralism as desirable but not necessary for criticism. Radical falsificationists hold the antithesis to Feyerabend's incommensurability claim: A common empirical basis can always be found. This means nothing else than the thesis of incommensurability would be a certain myth.[11]

## 3. A Falsificationist Interpretation of Observations with and without the Telescope

When Galilei observed Venus' brightness and size variations *via* the telescope which he constructed, he discovered that these observations are in accordance with the predictions of the Copernican theory (*CT*), but not with the predictions of the Ptolemaic theory (*PT*). The observations with the telescope yielded, for instance, to other values for Venus' brightness and size variations than observations without the telescope. Only the observations of these variations with the telescope agreed with the *CT*. Feyerabend argues that Galileo as supporter of the *CT* assumed the reliability of the telescope, whilst supporters of the *PT* doubted this reliability. Does this show, as Feyerabend intends, that the Ptolemaic and Copernican theory are incommensurable with respect to Optics?

In order to give an answer to the question of incommensurability from the view of critical rationalism, it is helpful, to distinguish clearly between two problems which can be expressed in the following questions: (1) What can be observed with the telescope? (2) Are observations with the telescope or with the mere eye reliable? The first problem is

[10] Feyerabend, *Science in a Free Society*, p. 228.
[11] Cf. Popper, K. R., “Normal Science and its Dangers”, p. 56.

*empirical*, the second *theoretical*. (1) is a problem of test statements, (2) a problem of accepted auxiliary hypotheses.

The test statements about the observations of the planets' brightness and size variations using the telescope, and the other test statements about the same observations but using the unequipped eye were relatively unproblematic. After the "childhood diseases" (i.e. the initial problems) of the telescope were overcome, an intersubjective agreement about the observations of the planets' variations with the telescope could be achieved. The observations of the same phenomena with the mere eye were never problematic. In contradistinction, it was problematic which type of observations was reliable, and thus could be accepted: The auxiliary hypothesis of the reliability of the naked eye ($AH_0$), or the auxiliary hypothesis of the reliability of the telescope ($AH_1$).

As long as the auxiliary hypotheses about the telescope and the mere eye were implicit, the impression could occur that the *PT* and the *CT* were incommensurable with respect to Optics; that means in this case that the supporters of both theories supposed different values for the planets' brightness and size variations (for instance Venus' values). However, critical rationalists presuppose the following: If the supposed auxiliary hypotheses can be expressed explicitly, then they can be discussed, and furthermore unproblematic test statements about the observations of Venus with the telescope and without can be established.

From a falsificationist perspective, Feyerabend's example does not show at all that the *PT* and the *CT* were incommensurable with respect to Optics, but that supporters of both theories supposed different auxiliary hypotheses. It is not to understand without further ado, why the reliability of the telescope has to be discussed "anarchistically", as Feyerabend claims, by rhetoric and propaganda. Instead of an anarchistic discussion, different auxiliary hypotheses could be discussed, that is for a falsificationist a normal scientific procedure. However, Feyerabend's example is nevertheless interesting; for it shows how important it is that problematic auxiliary hypotheses, which are implicit, can be made explicit. Only if such a hypothesis is explicit, it can be discussed and empirically tested. The history of science shows that problems could sometimes be solved first by expressing explicitly tacitly supposed auxiliary hypotheses; this is a necessary requirement to contest a (not anymore implicit) hypothesis.[12] The manifest auxiliary hypothesis, that the

[12] Copi, I. M., *Introduction to Logic*, p. 511: „Perhaps the most significant lesson to be learned from the preceding discussion is the importance of scientific process of dragging „hidden assumptions" into the open. […] Because they are hidden, there is no chance to examine such assumptions critically and to decide

planets' brightness and size variations can be observed by the naked eye, is an example thereof.

It is neither possible nor necessary to express always all implicit auxiliary hypotheses explicitly. But it is significant indeed that single implicit auxiliary hypotheses *can* be principially expressed explicitly. This possibility is of particular importance, if an implicit auxiliary hypothesis is problematic as it was the case in Galileo's time with $AH_1$ expressing that the telescope is a reliable instrument.

Nowadays, one wouldn't express ($AH_1$) explicitly, but one would treat this hypothesis as unproblematic background knowledge. In case this hypothesis should be problematised for any reason, it can be made explicit to any time, and thus be critically discussed. In the time of Galileo, it was highly problematic, whether the telescope would be reliable. Therefore it was back then desirable from an falsificationist point of view that ($AH_1$) was expressed explicitly.

Galileo and his opponents discussed whether the observations with the telescope or with the mere eye were reliable. It was a discussion about the validity of different auxiliary hypotheses. In contrast, the test statements of the observations with the naked eye and the telescope respectively were relatively unproblematic. Accordingly, Galileo did not doubt that Venus' brightness and size variations observed without the telescope are small; rather he doubted $AH_0$ expressing that the planets' variations can be observed reliably with the naked eye. For a falsificationist, the discussion about the auxiliary hypotheses had immense consequences. In case Galileo's conjecture $AH_1$ was correct, then the *PT* was falsified. In contrast, if the observations of the planets with the mere eye were reliable ($AH_0$), then the dispute between the two rival astronomical theories was not decided yet. Let us take a closer look at the historical dispute.

## 4. Galilei's Observations *en Détail*

Let me briefly restate Feyerabend's stance on Galilei's observations: He tries to show that Galilei defended the *CT* with *ad hoc* hypotheses which immunised falsifications. The

intelligently whether they are true or false. Progress is often achieved by formulating explicitly an assumption which had previously been hidden and then scrutinizing and rejecting it."

conducted observations of the planets' size variations without the telescope weren't in accordance with the predictions of the *CT*. In contradistinction, Galilei's observations with the telescope were in accordance with the predictions of Copernicus' theory. However, Galilei's optical auxiliary hypothesis of the telescope's reliability were established according to Feyerabend only after the *CT* has been introduced in order to immunise particular falsifications. Is Feyerabend right and thus Galilei's defence of the *CT* a defence with the help of *ad hoc* hypotheses? In this chapter I try to find an answer to this question, and to discuss the significance of Galilei's observations.

### 4.1. The Explanation of Venus' Phases

Let us consider the discussion about the planets' brightness variations. Some of the necessary optical auxiliary hypotheses were problematic, e.g. it was unknown whether the planets emit their "own" light, or radiate with reflected light. Since such auxiliary hypotheses were problematic, it is not astonishing that neither Copernicus nor Ptolemy tried to explain exactly the planets' brightness variations. Facing the problematic character of the auxiliary hypotheses, the problem was kept open. In any case we cannot speak of a falsification of the *CT* with unproblematic auxiliary hypotheses.[13]

Galilei's observations of the planets with the telescope showed a way how to resolve the open problem of the brightness variations. With the telescope the planets' variations could be observed clearly for the first time, and the observations agreed with the *CT*. The telescope also rendered possible to observe the planets' phases, especially the phases of the inner planets like Venus. Galilei was able to explain the almost constant brightness of Venus as follows: If Venus is at the nearest point relative to the Earth, then it looks crescent-shaped (like the new Moon). Hence, Venus is not that bright in Earth's proximity as one could have expected. If Venus is at the most remote point relative to the Earth, then it looks circular (like the full Moon). Since the whole illuminated surface of Venus is directed to the Earth (when Venus is at great distance from the Earth), it appears relatively

[13] In an anonymous preface to Copernicus' *magnum opus* (*De Revolutionibus Orbium Coelestium*) Osiander mentions the problem of the brightness variations in order to recommend an instrumentalistic interpretation of the *CT*. According to Feyerabend, Osiander shows that a realistic interpretation of the *CT* contradicted obvious facts (cf. Feyerabend, *Wider den Methodenzwang*, p. 144). Perhaps Osiander just wanted to diminish the expected resistance of philosophers and theologians against a realistic interpretation of Copernicus' theory.

bright. Venus' distance and size variations are almost entirely compensated by the variations of its phases.[14]

Galilei's observations showed how the problem of the brightness and size variations could be solved. Also the solution to some other problems were found thereby. For instance, before Galilei it was unknown, whether the planets emit their own light, or shine with reflected sunlight. Copernicus claimed that Venus has phases like the Moon, if it solely reflects light. Since such phases cannot be observed by the mere eye, Copernicus assumed that Venus is self-shining, or that it has a very extraordinary matter which is "fully saturated" by the sunlight. However, Galilei's discovery of Venus' phases shows that Venus has the predicted phases, and thus that it shines with reflected light.[15] In the face of this background knowledge, Galilei's introduction of new auxiliary hypotheses (in particular $AH_1$) does not seem to be *ad hoc*, but well-motivated.

From a falsificationist angle, it was even more important that the observations of Venus phases allowed for the first time a crucial experiment between Ptolemy's and Copernicus' theory. The planets' positions can be explained approximately equally well by both theories. In case the planets shine with reflected sunlight, both theories predict that the planets should show phases like the Moon. However, the theories predict different phases. The difference was especially clear when Venus was in a great distance to the Earth (i.e. for Venus in and near to the superior conjunction). As already mentioned, the *CT* entails that Venus at a great distance relative to the Earth should look circular ("full" Venus). The *PT*, *au contraire*, implies that Venus at a great distance relative to the Earth should look crescent-shaped ("new" Venus). Equipped with the telescope, Galilei was able to observe that, when Venus was in the superior conjunction, then it was almost full. The observation agrees with the *CT*'s prognosis, and falsified the *PT*. To this important observation Feyerabend merely comments that Venus' phases do not render the Copernican hypothesis of the Earth movement more evident, since it can also be explained by Tycho Brahe's geocentric theory.[16]

As P. Duhem had suggested before, Feyerabend argues that a crucial experiment cannot prove the truth of a hypothesis.[17] In a falsificationist methodology however, is the function of a crucial experiment not to prove a hypothesis, but to falsify one of two (or more)

[14] Cf. Price, Derek J. de Solla, *Contra-Copernicus*, pp. 197-218, especially p. 213.
[15] Cf. Galilei, *Dialog*, pp. 349-350.
[16] Cf. Feyerabend, *Wider den Methodenzwang*, p. 170 and p. 254.
[17] Cf. Duhem, Pierre M. M., *La Théorie physique. Son objet – sa structure*, pp. 252-53.

competing hypotheses. The observations of Venus' phases at a great distance relative to the Earth do not prove the truth of the *CT*, of course, this can no observation. However, the observations falsified the *PT*. This is important enough and shows that the observations with the telescope exceeded its propagandistic value.[18]

### 4.2. The Establishment of the Irradiation Hypothesis

From a theoretical point of view, the discussion about Galilei's observations with the telescope was a dispute between auxiliary hypotheses. Seen from the position of a consequent fallibilism, Feyerabend's claim is not astonishing that the first observations with the telescope were problematic. In contrast, his claim is astonishing that a rational discussion of the relevant auxiliary hypotheses is not possible. According to Feyerabend, Galilei could support the auxiliary hypothesis of the telescope's reliability ($AH_1$) only with irrational and anarchistic means. Feyerabend does not consider that $AH_1$ was independently testable from the astronomical theories, and as the history of science shows was indeed tested. Feyerabend's assumption that the $AH_1$ can only be discussed together with a new cosmology and a new world view seems to be inspired by a philosophically inspired holistic dogma.

Whether observations with the telescope or with the mere eye are reliable, is independent of the correctness of the *PT* or the *CT*. Galilei didn't claim that the telescope is reliable, because the observations with it agreed with the *CT*. In lieu thereof he tested the competing auxiliary hypotheses independently from astronomical theories. He observes that for example Jupiter appears brighter and greater (i.e. the apparent magnitude or size of Jupiter is bigger), if it is observed in total darkness. In the dawn, however, Jupiter appears pretty small when observed with the mere eye. The same counts for other bright planets. In order to explain these phenomena, Galilei establishes the hypothesis of *irradiation*. Against a dark background, bright and point-shaped objects are perceived too big. The emergence of such a misperception can easily be tested independently. The irradiation does not emerge, if there is no dark background, for instance, if a bright planet is observed through a hole in

[18] Cf. Popper, *Conjectures and Refutations*, p. 112, footnote 26: "Duhem in his famous criticism of crucial experiments […] suceeds in showing that crucial experiments can never *establish* a theory. He fails to show that they cannot *refute* it."

a white piece of paper or through a tube. Hence, Galilei says that an obstacle, which comes from the eye itself, plays an important role when you observe bright planets.

The irradiation hypothesis explains, why the observations of the planets' size variations with the naked eye didn't agree with the *PT* and the *CT*. The size variations were based on a misperception, the irradiation. Without the irradiation, the planets look point-shaped when observed with the eye. The planets' size variations are not observable without a telescope. With the telescope, Galilei was able to observe the variations, and that these variations were in accordance with the *CT*.

The discovery of irradiation enabled Galilei to criticise the auxiliary hypothesis of the reliability of the mere eye ($AH_0$). The auxiliary hypothesis of the reliability of the telescope could be tested independently by the observation of distant objects on the Earth. According to Feyerabend, the telescope impressed the – back then – contemporary literature as mean to improve the *seeing on earth*.[19] He claims, however, that the telescope's application in astronomy is another story. In order to show that the astronomical observations with the telescope were problematic, he offers the following reason: Galilei drew a moon crater too big.[20]

### 4.3. The Moon and the Explanation of the Telescope's Functionality

I argue against Feyerabend that Galilei's drawings of the Moon's surface in *Siderius Nuncius* do not show that the telescope was unreliable. In this first publication about his observations with the telescope it was not Galilei's aim to draw an exact map of the moon, but to show that there are mountains on the moon.[21] No high degree of exactness was required in order to refute the hypothesis of the Moon's perfectly spheric form. It was sufficient to show how the shadows and the bright parts of a Moon mountain changed by varying lighting. Galilei was content therewith to draw a Moon mountain – a bit too great and with varying lighting. If Galilei's problem situation is properly understood, then the pedantic objection that he hasn't drawn an exact map of the moon loses its justification.[22]

[19] Feyerabend, *Wider den Methodenzwang*, p. 139.
[20] Cf. Ibid, pp. 155-58, and Galilei, G., *Sidereus Nuncius*, p. 92.
[21] Cf. Galilei, *Sidereus Nuncius*, pp. 87-88. The unevenness of the Moon's surface wasn't a matter of course, but an important discovery, which falsified the Aristotelian hypothesis that the Moon is perfectly spheric.
[22] Cf. Galilei, *Sidereus Nuncius*. On p. 92 a Moon mountain is pictured with highly varying lighting.

Directly after *Siderius Nuncius* was published, in which Galilei reports on his observations with the telescope for the first time, Kepler mentioned the necessity to explain the telescope's functionality. Already in 1611 he succeeds to explain optically how Galilei's telescope functions and to specify how a better telescope can be constructed. Kepler's telescope was later commonly used for astronomical observations.

Feyerabend tries to show that Kepler's explanation of the telescope's functionality was unsatisfactory, because the explanation was based on falsified hypotheses. As falsification of Kepler's optic, he argues that an object, which is in the focal plane of a convex lense, is not seen infinitely distant if observed through the lense.[23] If one observes objects being in the focal plane of a convex lense, then the telemetric triangle reaches infinity (as Feyerabend notes). However, it does not follow from this that the objects are *seen* in an infinite distance. Kepler's geometrical optic is only a theory about how light rays are refracted in lenses. That the telemetric triangle reaches infinity means only that the light rays are after the refraction in a lense parallel. This prognosis of his geometrical optic is correct and can be tested independently by the experimental examination of the light rays' refraction in the focal plane of a convex lense. In contradistinction, the geometrical optic is not able to explain how objects are seen through lenses. Hence, Feyerabend errs when he negates that Kepler could explain the telescope's mode of functioning. Feyerabend's falsifying prognosis is not a consequence of Kepler's optic, his discussion is based on a fallacy. The telemetric triangle is in the geometrical optic only a mean in order to be able to calculate refractions of light rays. These refractions could be calculated approximately correct using Kepler's optic. *Summa summarum* Kepler could explain optically how the telescope functions as well as specify the plan for the construction of a better one.

### 4.4. Galilei's Incautious Defence of the Copernican Theory based on Reproducibility

*If* the auxiliary hypothesis of the telescope's reliability is correct, then Galilei's observations of Venus' phases and the planets' size variations falsify the *PT*. This is a conditioned falsification. If the telescope is reliable, and Venus is full in the superior conjunction, then the *PT* is false. This falsification requires not only test statements, but also the corroboration of the auxiliary hypothesis $AH_1$. Indeed, it is correct that Galilei did

[23] Cf. Feyerabend, *Wider den Methodenzwang*, p. 152, footnote 22.

not argue cautiously or hypothetically, that he didn't claim the Ptolemaic system is falsified, *if* the telescope is reliable. Instead he claimed with great confidence that the telescope is reliable and thus the *PT* falsified. However, this does not show that rhetoric and propaganda played an important role. Galilei's auxiliary hypotheses were criticised by many other scientists. The acceptance of Galilei's observations with the telescope is less based on his skillful argumentation than on the reproducibility of his observations. Presumably, the most artful rhetoric would not have been sufficient in order to convince Galilei's numerous opponents of the existence of Venus' phases, if they had not been able to observe them with the telescope on their own.

Feyerabend objects that the reproducibility of a phenomenon does not show its "reality character".[24] This is correct. Many misperceptions, e.g. the irradiation of bright planets, are reproducible. The problem, however, is not to show or to prove that phenomena have a "reality character", or that observations are reliable. Such proofs are not possible from a falsificationist angle. The problem is to criticise the reliability of observations, to give arguments which are directed against the "reality character" of phenomena. In order to show that there is a misperception, some reproducible counter-experiment needs to be specified. In his discussion of the irradiation, Galilei specified such experiments, what Feyerabend desists in his discussion about the telescope's reliability. In place of specifying reproducible counter-experiments, Feyerabend contents himself with discussing some problematic single-observations like Galilei's first drawings of the Moon.

## 5. A Rational Reconstruction of Galilei's Falsification of the Ptolemaic Theory

According to Feyerabend, Galileo protected the Copernican theory (*CT*) against criticism by introduction of a new optical auxiliary hypothesis ($AH_1$), namely that the telescope is a reliable instrument for the observation of the planets' brightness and size variations. This new $AH_1$ does not modify the *CT*, but is a necessary auxiliary hypothesis: without this hypothesis Galileo wouldn't have been able to use observations *via* telescope in order to

[24] Cf. Feyerabend, *Wider den Methodenzwang*, p. 153, footnote 22.

test the theory. $AH_1$ thus does not modify the *CT* as Feyerabend claims, but the whole theoretical system which is used for the deduction of predictions.

In order to derive from the Ptolemaic theory (*PT*), and boundary conditions (*I*) a prediction (*P*), the auxiliary hypothesis $AH_0$ of the reliability of the naked eye is used:

(1) $I, PT, AH_0 \vdash P$

If *P* is not observed as it was actually the case, then the theoretical system, that consists of the conjunction of *PT* and $AH_0$, is falsified.

(2) $I, \neg P \vdash \neg(PT \wedge AH_0)$

It is possible that the falsification grounds on the falsehood of $AH_0$. Therefore, it is a rationally legitimated research strategy to replace the old $AH_0$ by a new $AH_1$; this means that a part of the theoretical system, namely $PT \wedge AH_0$ is modified to $PT \wedge AH_{i\neq 0}$.

The modification can be interpreted methodologically not only as immunising a falsification, but also as modification of a part of the system, as an attempt to learn from experience. From the falsificationist point of view, Galileo took such a modifying step when he rejected $AH_0$, and replaced it with $AH_1$.

Galileo claims that his observations with the telescope falsified *PT*. His falsification supposes $AH_1$. Concerning such falsifications, one does (until further examination) not know that just the very *PT* as part of the tested system is false, except one presupposes the dogmatic assumption that $AH_1$ is true; but this is unfamiliar for a falsificationist in contrast to a epistemological anarchist.

In case an auxiliary hypothesis is independently testable with respect to the corresponding theory, and the auxiliary hypothesis corroborates, then such a hypothesis can be used as falsifying premiss:[25]

(3) $I, AH_1, \neg P \vdash \neg PT$

Suppose $AH_1$ is not independently testable. Then one can express oneself more cautious:

(4) $I, \neg P \vdash (AH_1 \rightarrow \neg PT)$

[25] The formalisation renders the following manifest: Some hypotheses or even an isolated hypothesis is sufficient in order to derive a prediction just in case a part of the theory (i.e. the hypotheses) or a single hypothesis respectively is independently testable from the entire theoretical system. Thus it is a conventionalist myth that always a whole theoretical system is tested or even the total knowledge; for, it is possible that auxiliary hypotheses, which are necessary to derive empirical prognoses from a theory, can be tested independently from a theory (or even some theories). In this way, the $AH_1$ could be tested independently from the *CT* and the *PT*.

(4) says that *PT* is false, if $AH_1$ is true. In this sense, a falsificationist can assert that *PT* is falsified, if Galileo's observations *via* telescope are reliable.

Auxiliary hypotheses used to deduce empirical predictions do not need to immunise falsifications; *au contraire*, they can be used in order to enable additional empirical tests. Considered this way, auxiliary hypotheses do not serve to immunise falsifications, but to test theories as strict as possible. The impression of theory-immunising only occurs, if one does not take into account that in these cases whole theoretical systems are empirically tested. If the holistic or systematic character of the empirical test is considered, then the use and modification of auxiliary hypotheses is neither an expression of an epistemological anarchism nor theory-immunising, but an application of the hypothetico-deductive method. A falsificationist can thus conclude: In the discussion of both astronomical theories, $AH_1$ could be tested independently from *PT* and *CT*, and hence be used as falsifying premiss. In this way, Galileo's observations (of Venus' phases) falsified the *PT*.

## 6. Evaluation

According to Feyerabend, Galilei's defence of the Copernican theory (*CT*) against the Ptolemaic theory (*PT*) shows that the two theories are optically incommensurable. Equipped with the telescope, Galilei was able to conduct observations which falsified the *PT* and were in accordance with the *CT*. These observations, as Feyerabend notes correctly, were not accepted from many proponents of the *PT*, because observations with the mere eye led to partly other results. Therefore, since competing theories would be restricted in their empirical comparability, the value of a falsificationist methodology (albeit not logically impossible) would decrease significantly. In consequence, he is fooled into believing that the transition from one theory to another is essentially the result of rhetoric and propaganda.

In Feyerabend's view, the history of science shows that falsified theories can often be further developed. This is the reason why it would be irrational to abandon them. In particular new theories would have to struggle with considerable difficulties until the necessary auxiliary hypotheses have been established. In this way the *CT* would have been

falsified from its birth, and Galilei could only immunise the *CT* against falsifications with the help of successively introduced *ad hoc* auxiliary hypotheses.[26]

As we have seen, a falsificationist methodoloy is able to reply Feyerabend's theoretical view about the Copernican revolution, and to provide a rational reconstruction of Galilei's falsification of the *PT*. In particular, even a modest falsificationist rejects Feyerabend's claim that the *PT* and the *CT* would be optically incommensurable. For, in this case it is possible to resolve the problem of incommensurability by using optical auxiliary hypotheses to test the theories in order to deduce relatively unproblematic test statements. If these test statements do not happen to be true, the respective theory is falsified provided that the particular auxiliary hypothesis can function as falsifying premiss, that is, if the premiss is independently testable.

The impression of incommensurability of competing theories emerges due to Feyerabend's belief that theory-dependent experience cannot be discussed rationally. But this does not need to be true as the case of Galilei's observations exemplifies: The auxiliary hypothesis of the telescope's reliability was independently testable from both of the astronomical theories, and the implicit and competing auxiliary hypotheses ($AH_1$ and $AH_2$) could be expressed explicitly, and thus be topic of a critical discussion; above that, in the discussion, the test statements which corresponded to the problematic auxiliary hypotheses were relatively unproblematic. Seen in this light, Galilei defended the Copernican cosmology according to the methodological scheme of falsification.

I can conclude that a critical rationalist can counter Feyerabend the following: It is a myth that the theory-dependence of experience leads thereto that different theories (world views, paradigmata, cosmologies, etc.) cannot be discussed rationally. This philosophically inspired myth dubbed Popper "*The Myth of the Framework*" and designated it as the central bulwark of irrationalism.[27] If one chooses this myth as base of his theoretical views,

[26] I do not argue against Feyerabend's claim that new and promising theories should be protected at the beginning. However, one should thoroughly inspect if there really are immunising *ad hoc* hypotheses. Above that, it is unclear to me what it means for a hypothesis to be *ad hoc*.

[27] Popper, "Normal Science and its Dangers", pp. 56-57, his italics. Popper states that the myth of the framework "exaggerates a difficulty into an impossibility. The difficulty of discussion between people brought up in different frameworks is", he writes, "to be admitted." He continues with his counter-thesis a few lines below that "in science, as distinct from theology, a comparison of the competing theories is always possible." (Ibid., p. 56-57) I am not sure, if such a discussion is always possible like radical falsificationists claim. Be that as it may, we should first try and examine, if a discussion is possible (and perhaps even fruitful) and not jump to conclusions in a premature way as Feyerabend does concerning the *PT* and the *CT*. After we examined, whether a critical discussion is possible, there is plenty of time left to admit that a comparison or discussion is not possible *in this case*.

then the philosophical way leads straightforwardly to the thesis of incommensurability, and to the therewith conjoined meander of epistemological anarchism.

Without being a convinced falsificationist, I showed that a falsificationist methodology is superior to Feyerabend's epistemological anarchism, since the former can explain his prime-example, i.e. Galilei's observations, more adequately without recourse on anarchistic means. In the first instance, this does not sound like an interesting result. But if one considers that vast parts of Feyerabend's criticism directed to critical rationalism are based on this example, then one should let the result sink in again. The result suggests the attempt to investigate in a similar way other historical case studies which are directed against falsificationism, before one engages anarchistic means for the explanation of science's development.

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