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Beiträge zur Physik der Atmosphäre, gewidmet Dr. Manfred Reinhardt zum 65. Geburtstag

Contributions to Atmospheric Physics, in Honor of Dr. Manfred Reinhardt to his 65th Birthday

Ulrich Schumann und Klaus-Peter Hoinka (Hrsg.)

DLR
Institut für Physik der Atmosphäre
Oberpfaffenhofen

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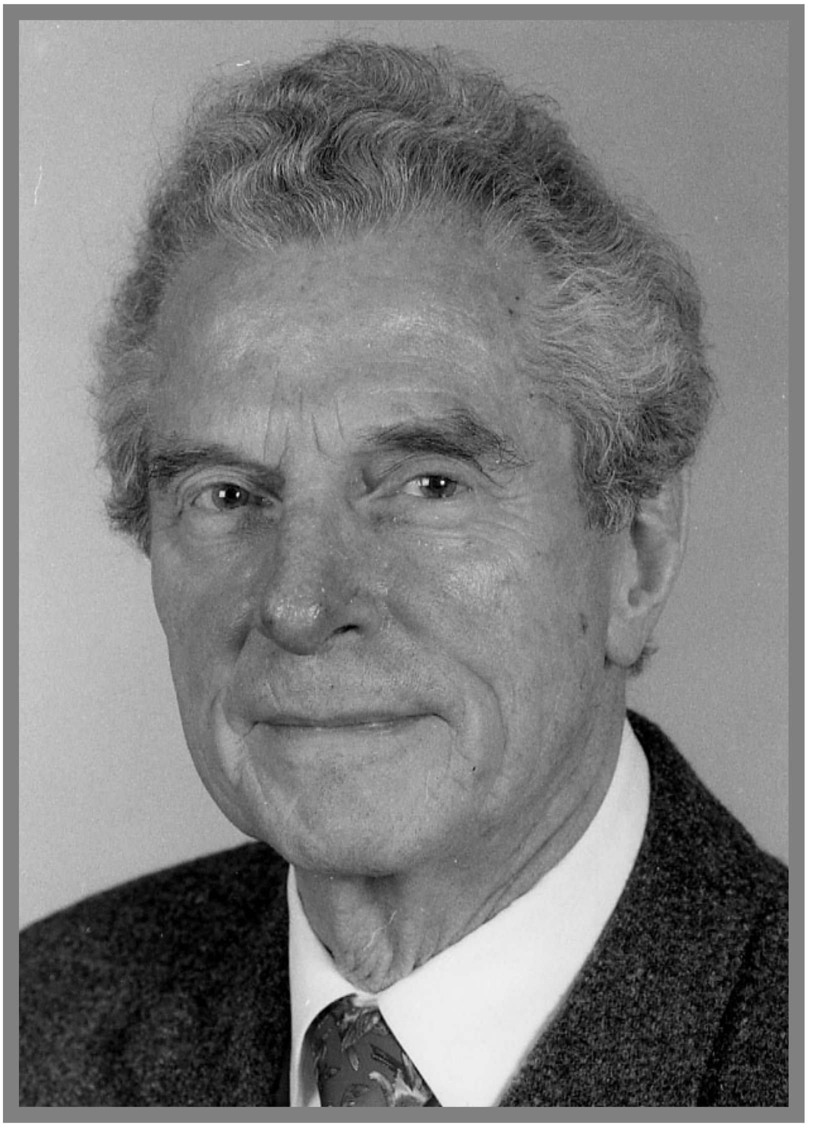

Manfred Reinhardt feierte am 26. Januar 2007 seinen 80. Geburtstag. Eine Woche später widmete ihm „sein“ DLR-Institut für Physik der Atmosphäre ein Kompakt-Kolloquium mit sechs Kurzvorträgen zum Thema

„Die Atmosphäre: Wechselwirkungen in Raum und Zeit“

Der nachfolgende Text ist 15 Jahre alt. Er wurde in kleiner Auflage noch einmal gedruckt und beim Kolloquium an Interessenten verteilt, weil er sich bereits damals mit dem Jubilar und Wechselwirkungen in Atmosphäre, Raum und Zeit intensiv beschäftigte – in der solch schwierigen Themen angemessenen Ernsthaftigkeit.

Oberpfaffenhofen, den 2. Februar 2007 Hans Volkert

On the Existence of a Capital Similarity

Hans Volkert
DLR, Institut für Physik der Atmosphäre

Abstract

Abstraction is an important tool in scientific reasoning from its very beginning more than two millenia ago. Working with analogies and similarities constitutes an essential part in the abstracting process. This note briefly reviews the historical background and some similarities commonly used in the field of (geophysical) fluid dynamics and finally postulates a new, so far overlooked similarity. The study is short, but considered to be potentially seminal as a plethora of future research projects may be launched into the concept of "capital similarity".

1. Quick march through history

Comparing facets of the overwhelmingly complex reality surrounding us with each other and with ideas, hypotheses or theories that have been put forward is the very basic process which scientists pursue every day all over the globe. As far as we know Anaxagoras of Klazomenai (approx. - 460) was the first who formulated the technique of reasoning by analogies as a basic way of thinking in his frequently quoted sentence:

ὄψις γὰρ τῶν ἀδήλων τὰ φαινόμενα ,

which roughly means that "revealing the unseeable is achieved by looking at the discernible phenomena".

Let us step forward about 21 centuries into the 1680ies. As is well known from physics lessons in school Newton was then among the most able abstracters as he found apple and earth, earth and moon, as well as planets and sun similar or analogous in their respective gravitational interaction. Less known is perhaps that he also had deep insight in the properties of gaseous fluids such as the compression force and the resulting pressure (Newton, 1687), which bridges the way to fluid dynamics and meteorology.

Before arriving there we stop another 22 decades later, just after the turn of our century. Einstein and others produced a well received earthquake for the seemingly rock solid building of physical theories. *Inter alia* the idea of a medium in which electromagnetic waves travel ("Lichtäther" or ether) was found to be superfluous (Einstein, 1905; p. 892). V. Bjerknes was - among others - very much frustrated by this revolution and, thus, slowly turned his interest to the ether around our planet, *vulgo* the atmosphere. During the following years he and his co-workers appropriated the weather, constructed a modern meteorology and developed the celebrated cyclone model with fronts and the other ingredients which we still find on today's weather charts (see e.g. the detailed biography by Friedman, 1989). We note, as an aside, that at the beginning of 1927 the "golden years of the Bergen school" (Drazin, 1990) had just ended and M.E. Reinhardt (MER for short) was born in Wildberg on the hills of the Black Forest.

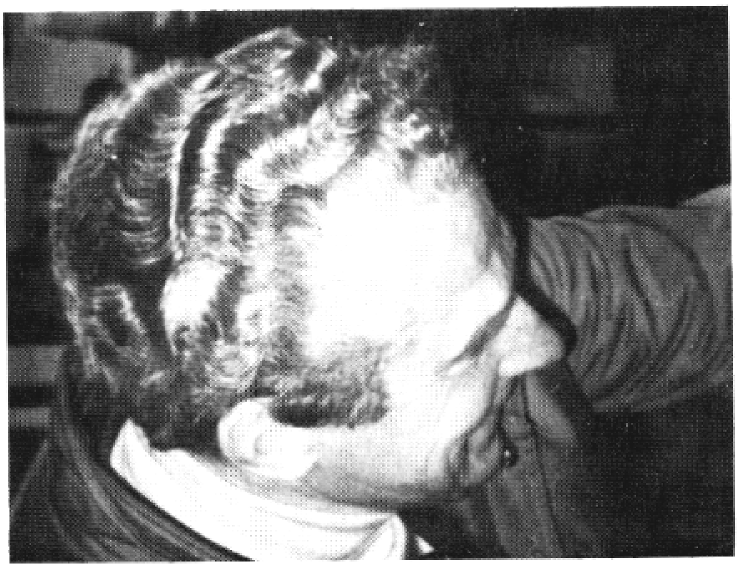

Fig.1: Typical observer as seen from an elevated position. Photograph of MER in autumn 1990 while bending down at his desk and spotted by his secretary U. Löb; snapshot rotated by 90° in the anticlockwise direction.

The history of physical abstraction to higher and higher levels still continues (see e.g. Faessler, 1991) while we now turn to inspecting similarities in fluid dynamics in some more detail.

2. Similarities in fluid dynamics

This paragraph can be concise indeed as good introductions to the purpose and principles of similarities are given in well known textbooks. Batchelor (1967), for instance, devotes his chapter 4.7 to "Dynamical similarity and the Reynolds number". There he states:

> "This principle of dynamical similarity is used widely as a means of obtaining information about an unknown flow field from 'model tests', that is, from experiments carried out under physical conditions more convenient than those of the unknown flow field."

Key quantities are non-dimensional numbers (e.g. the Reynolds number) which allow to obtain a single fundamental equation for a whole variety of situations.

In boundary layer meteorology one frequently meets the term "similarity theory", which Stull (1988) uses as a headline for chapter 9 of his detailed textbook. Following the Buckingham Π theory one groups the relevant variables into non-dimensional groups by a dimensional-analysis procedure. It is then

> "... hoped that the proper choice of groups will allow empirical relationships between these groups that are 'universal' - namely, that work everywhere all the time for the situation studied."

As examples Stulls mentions "Monin-Obukhov similarity", "mixed-layer similarity", "local similarity", "local free convection similarity", and "Rossby-number similarity".

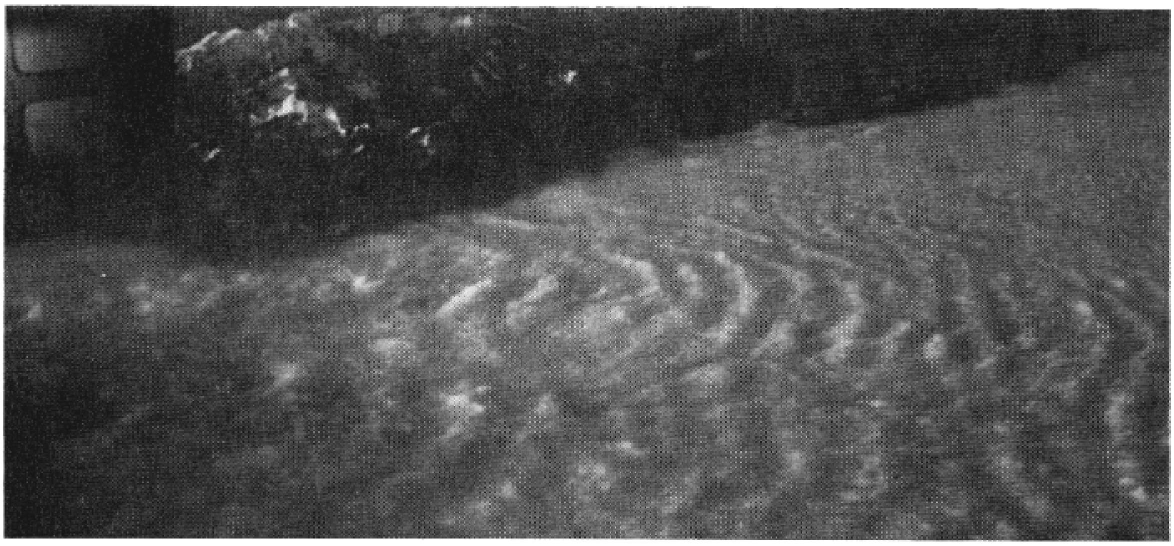

Fig.2: Sample phenomenon observed by MER (cf. Fig.1) from a commercial airliner at approx. 8km over Rosenheim at about 06 UTC on 18 March 1987 (Reinhardt, 1991). The Wendelstein massif (1832 m) can be seen right of the engine; over a dozen curved wave crests impressed on a layer of low stratus are discernible.

The author feels certain that the variety of similarities in the literature is much larger, but he is not aware that the "capital similarity" has been mentioned before.

3. Striking example of capital similarity

Batchelor related awful unknown flows to friendly model situtations. We propose to compare a complicated phenomenon with the clear cut appearance of its observer. Without much loss of generality we put forward the following striking example, which inspired the concept of capital similarity. In Fig. 1 the *caput* (Latin for "head") of an experienced observer is displayed. The capital surface is covered by dense hair exhibiting a regular wave-structure with RN = 3 (the "Reinhardt number" counts the wave crests along a front-rear cross-section above the right ear).

Immediately the question arises which objects could attract this observers attention. A brief and certainly incomplete view into the literature reveals *inter alia*:

- sensitively sensed temperature structures (Reinhardt und Franz, 1960),
- waves at an inversion over Newfoundland (Müller und Reinhardt, 1966),
- Alpine modification of sensible heat flux in the atmosphere (Reinhardt, 1971),
- wavy structures in the horizontal component of the electric field within the troposphere (Reinhardt, 1972; cf. Fig. 20),
- wave patterns in the refractive index as seen by airborne LIDAR (Mörl et al., 1981),
- horizontal distribution of heat fluxes measured by motorgliders (Reinhardt, 1985), and
- convection patterns and hailstone analysis (Höller and Reinhardt, 1986).

Fig.3: Typical observer's appearance (on the left) at the end of the 1950ies during a discussion in front of an aircraft hangar.

The observer clearly appears to have wide interests, but various wave phenomena seem to have attracted his attention throughout the years. Having been a keen glider pilot since his student days with Akaflieg Stuttgart he was acustomed to look up into the sky to discover large amplitude foehn waves, which he then used as a means of reaching high altitudes in a sailplane. But Fig. 2 reveals that he also could look down from an aircraft, discover and document waves impressed on a pre-Alpine stratus layer (as was seen before, e.g. during a Spacelab mission; cf. Volkert, 1985).

Let us lean back and carefully compare Figs.1 and 2. After some tenths of a second most readers may utter "amazing" or "erstaunlich" or the like. This marks the sudden, intuitive awareness of the capital similarity between observer and observed phenomenon. In the stratus, there are approximately four times as many waves crests and they exhibit larger along crest extension, but the characteristic curvature is equally present in Figs.1 and 2.

A lot of interesting questions arise, as "what is the stability and typical flow speed of the air above the waves?" or "is linear lee-wave theory applicable?". But of higher relevance seems to be an investigation concerning the possible interaction between observer and object. To put it bluntly: did the observer's hair turn wavy because of the observation?

Fig. 3 tells us: "no". MER's head has exhibited waves for at least the last 30 years. Moreover, RN seems to have decreased from 5 to 3 over the span of three decades. It is not completely clear whether MER's appearance caused the waves on the stratus top, but it is certain that his head was necessary to observe and document them.

Now, we do the step which is small for the experienced scientist but may well be large and important for mankind. Capital similarity between observer and object is an existing phenomenon. As another realisation one may think of a bald scientist experimenting with laminar flows. In passing we note that this concept is in direct succession to the 2500 year old Anaxagorian principle quoted in section 1.

4. Critique and outlook

Some of the super critical readers may oppose this study by simply stating that a new kind of similarity cannot be introduced by presenting just one example, however striking. We answer with a highly relevant quote (with has another quote embedded):

> "as noted by the eminent Dr. Grant Swinger, '... we don't finalize any problems. We confine ourselves to pioneering in developing new approaches ... (Greenberg, 1981)'. ... A numerical model ... has been developed, but any further refinement of these specifications is likely to come from other sources" (Geotis and Smith, 1984).

So, obviously, any harsh critics of our approach have to be considered as misplaced. The field is now wide open for interdisciplinary research to quantify the relevance of the capital similarity for the advancement of science in general and to assess its impact on society in particular.

All readers, who find this study too verbose and void of formulae are referred - just for a change - to Filser and Thoma (1966).

Acknowledgements:

The author feels seriously indebted to Manfred E. Reinhardt who made this study possible in a two-fold way. Firstly, he initiated the postulate of the existence of the capital similarity by his physical appearance and his vivid interest in wave phenomena. Secondly, he did not impede the evolution of a working atmosphere within the Institut für Physik der Atmosphäre that allowed vague ideas to blossom and ripen slowly but steadily. It is hoped that this atmosphere will prevail after MER's retirement at the end of 1991. Hartmut Höller and Martin Hagen are thanked for bringing the extraordinary studies by Filser & Thoma and Smith & Geotis, respectively, to the author's attention. The assistance of Alan J. Thorpe is especially appreciated as he contributed some vocabulary which may make this text readable also for experienced readers of British journals (e.g. Q.J.R.Meteorol.Soc. or Punch).

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