

How Lecture Notes Reflect the States of Science and of Technology: From Vilhelm Bjerknæs' Type-Scripts of 1914-17 to pdf-Files in 2004

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1 Introduction

Various paths exist how scientific knowledge is spread and passed from one generation to the next. While original research papers in journals report on novel findings, textbooks for university classes tend to contain what the author(s) consider as a more consolidated form of the state-of-the-art. Lectures notes prepared by professors for their students take an intermediate position in this process. Although they may be provisional in character, they carry the potential to provide a closer view to the development of ideas.

The starting as well as the central point of this contribution are two sets of lecture notes, which Vilhelm Bjerknæs prepared during his short, but influential time at the university of Leipzig. The knowledge of their existence and a flavour of their appearance is to be passed to interested parties of the international atmospheric science community, and students in particular. The usage of the German language a medium for scientific communication by a foreigner is touched upon, including some personal memories about Vilhelm Bjerknæs in the Leipzig during the 1920ies and 1930ies by the third author. Additionally it is attempted to reflect the increasing ease of duplicating lecture material for the class-room and how this affects the tradition, *i.e.* passing on, of knowledge.

2 Vilhelm Bjerknæs's lecture notes

The Geophysikalische Institut of Leipzig university was founded in January 1913. It was first housed in a fleet of rooms in Nürnberger Straße (Figure 1). The then 50 year old Vilhelm Bjerknæs was its founding director. His gradual move from theoretical physics towards applications in geophysical fluid dynamics is well documented, by himself and later on¹.

¹ see e.g. Bjerknæs 1933; Friedman 1989; Volkert 1999; Thorpe et al. 2003

There exist two sets of extended lecture notes on dynamic meteorology by Vilhelm Bjerknes from the four years which he spent in Leipzig. The set of 1914 contains 250 pages with 8 chapters (e.g. Skalar and vector fields, Infinitesimal motions and vortices, Dynamics of circulation and vortex motions, Consideration of the Earth's rotation), the one of 1917 has 200 pages containing eight sections with related but different titles (e.g. Equations of motion of a material point, Equations of motion for ideal fluids, Vector quantities in the hydrodynamic equations, Circulation and vortex motion). Figures 2 and 3 exemplify the general layout with double spaced typed text in the left column of the page in folio format (somewhat larger than A4) with formulae included in or pencil and some



Figure. 1: First home of the ‘Geophysikalisches Institut der Universität Leipzig’. Vilhelm Bjerknes and his group occupied a fleet of rooms in the first floor of this house in Nürnberger Straße 57.

sketches on the right hand side. We assume that Vilhelm Bjerknes used these notes as *aide-mémoire* for his two-hours-per-week summer term lectures of 1914 (*Dynamik idealer Flüssigkeiten mit Anwendung auf Luft- und Meeresbewegung*) and 1917 (*Ausgewählte Kapitel aus der Dynamik der Atmosphäre und des Meeres*), respectively. Two copies exist of both sets of notes, the originals at the library in Leipzig, carbon copies with differing handwritten entries at the Bayerische Akademie der Wissenschaften in Munich (in the collection of Weickmann papers). In combination with the existing official inventory of lectures (Vorlesungsverzeichnis) and the very vivid account of the everyday life in the young university department at Leipzig a decade later² it becomes evident that the lecture notes are an ex-

² Haurwitz 1985

plorative attempt to transpose rigorous physical reasoning from simple situations to more complicated settings in the atmosphere. Good hints to the combination of Bjerknes's pretension, sometimes also pathos, are contained in his inaugural lecture, which was printed by the renowned publisher Vieweg³.

Two small samples are reproduced in Figures 2 and 3 one each from the sets of 1914 and 1917. They are related to the discussion about circulations in the atmosphere, a topic that interested Bjerknes since the formulation of his circulation theorem in 1898⁴. The discussion is only qualitative, but relates supposed horizontal movements of air masses on the globe with compensating vertical motions (somehow resembling Rossby's definition from the late 1930s of a potential vorticity with a certain reference latitude; "In einer gewissen mittleren Breite ist die [relative] Circulation Null"; Figure 2). In the later sketch emphasis is put on the vertical motion, combined with the claim that vortex tubes raise from the ground in region

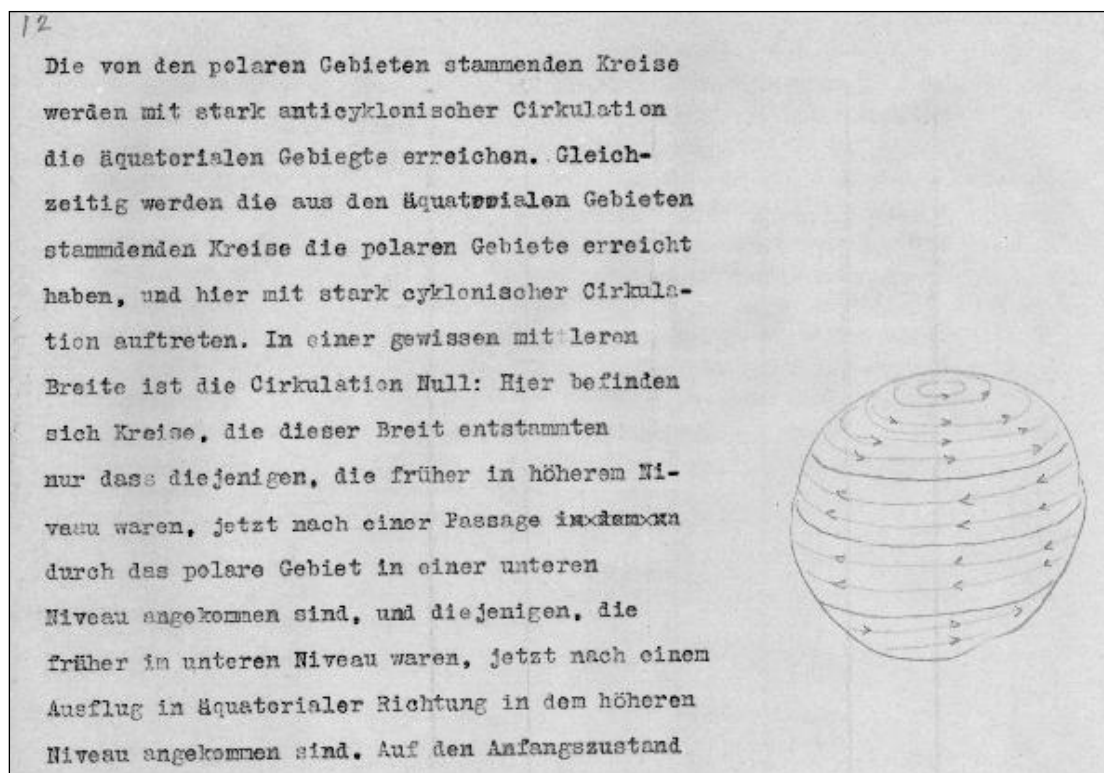


Figure 2: Example from lecture notes of 1914: page 12 of Chapter VII „Taking into account the Earth's rotation“. Doubled spaced typed script in the left column, idealized sketch of the global circulation along latitude circles (in pencil) in the right one.

³ Bjerknes 1913; see also Friedman 1989, p. 87

⁴ cf. the review of that development in Thorpe et al. 2003

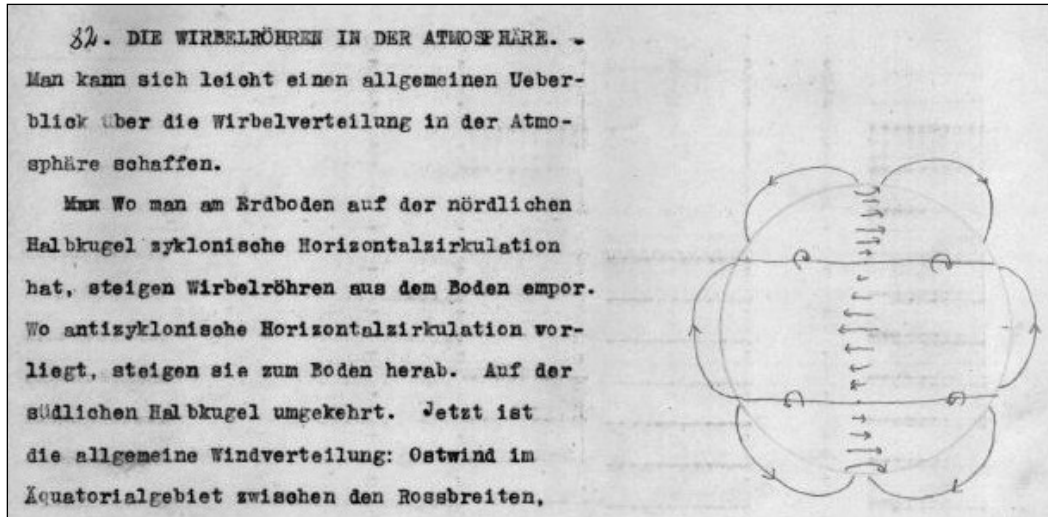


Figure 3: Example from lecture notes of 1917: Begin of Section 82 „Vortex tubes in the atmosphere“. Doubled spaced typed script in the left column, idealized sketch of the three-dimensional global circulation (in pencil) in the right one.

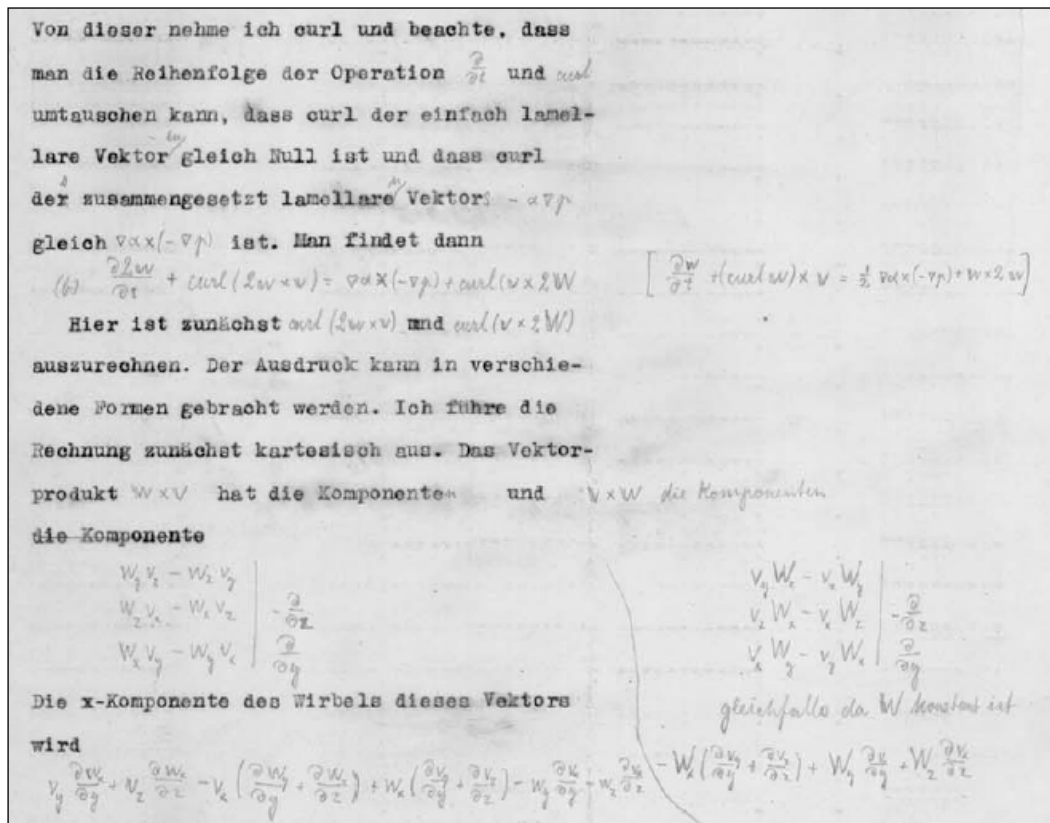


Figure 4: Sample illustrating mathematical analysis in modern looking vector algebra involving differential operators as rotation (curl) and gradient (inverse Δ). The section belongs to the derivation of the vortex theorem where \mathbf{w} and \mathbf{W} designate relative and absolute angular momentum vectors, respectively (lecture notes of 1917, p. 192).

of cyclonic circulation (“Wo man am Erdboden auf der nördlichen Halbkugel zyklonische Horizontalzirkulation hat, steigen Wirbelröhren aus dem Boden empor”; Figure 3).

An example of a lengthy mathematical derivation is given in Figure 4, where the x-component of the rotation (Wirbel) of a vector product is exemplified. It appears that these notes served Bjerknes as an *aide-mémoire* for the exposition on the blackboard of a classroom.

3 Inferences from the lecture notes

We see several lines of historic interest which can use these 90 year old scripts as a starting point: *i)* How was the young discipline of dynamic meteorology taught at the beginning of the 20th century by one leading figure in the field? *ii)* To what extent contain his lectures novel findings and which of them are still considered valid today? *iii)* How was German as a scientific language used by a foreigner from Norway? *iv)* Are there traces from the lectures notes to the detailed textbook on *Physical Hydrodynamics with Applications to Dynamical Meteorology* by Bjerknes *et al.*, which appeared in 1933?

Let us briefly follow the third of these lines as language barriers are typically not considered when the development and tradition of scientific ideas are described. Between world wars I and II the German language carried still much of its status as one of the important media for scientific communication. From the perspective of a well observing boy Vilhelm Bjerknes spoke German fluently (see appendix). An inspection of the lecture notes corroborates this finding. They are written in a careful style in often long sentences with numerous clauses, obviously influenced by a sound training in classical languages. Occasionally typing errors are corrected in pencil (*e.g.* missing capital letters for nouns or left-out duplication of consonants). In the 14 page appendix of a paper by Bjerknes *et al.*⁵ no less than 48 hydrodynamic publications are mentioned which were written by Vilhelm, his father, his son and a few other collaborators during the period 1863 to 1930 in his native tongue Norwegian as well as in German, English and French (however, the foreword of this long treatise in German mentions lingual assistance by the then young, later renowned scientists Schlichting and Haurwitz; recollections of his studies with V. Bjerknes and L. Weickmann sen. are also published⁶). The lecture notes evidently contain some

⁵ Bjerknes *et al.* 1933; pp. 777-790

⁶ Haurwitz (1985)

basic raw material of the polyglot multi-generation publication enterprise of the Bjerknes family. In his extended scientific biography of V. Bjerknes Friedman⁷ provides only indirect hints to the former's linguistic skills, *e.g.* studies in Germany with Hertz and extended visits to Paris. In the section *Bjerknes's Leipzig School* Friedman mentions lectures on *Statics* and *Kinematics*⁸.

A quick inspection of part two *Applications to Meteorology*⁹ reveals that mean global distributions, as in Figures 2 and 3, continue to be of interest to the authors. For instance, a circumpolar chart of monthly mean surface isobars on the entire southern hemisphere¹⁰ shows that the class room sketches of 1914 and 1917 qualitatively hold also 15 years later in printed form.

More generally, the lectures notes may be used a unique starting point for a consideration about the influence of the increasing ease of duplication technology on the tradition of lectures given at universities. The early personal notes of professors occasionally appeared as books, *e.g.* examples in the German language tradition with numerous small sections, sometime collected in chapters by Exner¹¹, Haurwitz¹², and Raethjen¹³ [only the later example of Pichler¹⁴ uses a three-digit decimal structure]. Later photocopied hand-outs provided students with basic material, while meanwhile downloading of complete manuscripts or presentation slides appears to have become quite common practice, both in universities or special purpose summer schools for advanced students and interdisciplinary exchanges¹⁵.

Whether the ease of duplication at the expense of copying by hand writing really helps learning, memorizing and understanding remains an open question. Clearly this contribution can at best stimulate interest with historians of science to also consider the various forms of lecture notes during the 20th century when pathways for the tradition of knowledge are studied (interested parties can receive from the first author a 40-page-sample taken from both sets of Bjerknes's lectures notes in electronic format).

⁷ Friedman (1989)

⁸ Friedman 1989, p. 91

⁹ Bjerknes et al., 1933

¹⁰ Bjerknes 1933, p. 633, Fig. 105

¹¹ Exner (1917)

¹² Haurwitz (1941)

¹³ Raethjen (1953)

¹⁴ Pichler (1983)

¹⁵ *e.g.* Zardi and Rotunno 2004

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Annex: Memories about Vilhelm Bjerknæs's later visits to Leipzig
by Ludwig A. Weickmann (*1919)

During the 1920ies and 1930ies Vilhelm Bjerknæs visited Leipzig several times. At these occasions he was a guest in our home, a fairly large apartment close to the *Völkerschlacht-Denkmal* and about 5 km from the Geophysical Institute. I don't remember much of these visits as my father [Ludwig Weickmann sen.; professor in Leipzig 1923-1945; cf. Börngen und Weickmann 2003] and our guest left soon after a talkative breakfast and returned quite late. Bjerknæs had spoken German fluently, so I hardly regarded him as somebody coming from abroad. Initially they must have used the tram to reach the institute. Later a car was available and used also for visiting the Geophysical Observatory at the Collm, a hill some 50 km to the east of Leipzig. During one of the visits Vilhelm was joined by his son, young Jacob [Jack] Bjerknæs.

While these visits in our home did not really interfere with my boyhood life, I remember one evening when V. Bjerknæs and my father returned very late and somewhat tipsy. The reason for this totally unaccustomed appearance I learned much later. At that time medium-range weather forecasts were not yet officially available. Therefore the famous Leipzig wine merchants Fertsch & Simon used to contact the Geophysical Institute whenever they had a risky wine transport during the winter. As compensation for the forecasts the institute's staff was invited once per year into their wine cellar. At one such occasion V. Bjerknæs joined the group. When at a late hour the question of "closing the session" came up, Bjerknæs as senior of the group made the following proposal (in German):

“Jetzt stehen wir alle auf, und wenn wir noch stehen können, setzen wir uns wieder. Wenn wir nicht mehr stehen können, dann gehen wir.“ (Translation: Now everybody stands up. If we are still able to stand, we sit down again. If we can't, we leave. – I would be reluctant to call this a “Bjerknæs Theorem”, but from the result at home there appear to have been some iterations).

Vilhelm Bjerknæs's last visit to our home must have been in 1938 at the occasion of the 25th anniversary of the Geophysical Institute, founded by him in 1913. During the following year World War II began and interrupted the long lasting friendship with my father. Being in Leipzig on 4 December 1943, the day of severe bombing of the town, I was the last one to leave the burning study room of my father. From the wall behind his desk a large photographic portrait of Vilhelm Bjerknæs looked serenely at me through the smoke