

How lecture notes reflect the states of science and of technology: From Vilhelm Bjerknes's type-scripts of 1914-17 to pdf-files in 2004

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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.

Vilhelm Bjerknes's lecture notes

The *Geophysikalische Institut* of Leipzig university was founded in January 1913. It was first housed in a fleet of room in Nürnberger Straße (Figure 1). The then 50 year old Vilhelm Bjerknes (Figure 2) was its founding director. His gradual move from theoretical physics towards applications in geophysical fluid dynamics is well documented, by himself as well as later on (see e.g. Bjerknes 1933; Friedman 1989; Volkert 1999; Thorpe et al. 2003).

The starting point of this presentation are 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 8 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 3 and 4 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 ink or pencil and some 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 later (Haurwitz 1985) it becomes evident that the lecture notes are an explorative 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 Vieweg (Bjerknes 1913).

Two small samples are given in Figures 3 and 4, 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 1898 (cf. the review of that development in Thorpe et al. 2003). The discussion is only qualitative, but relates supposed horizontal movements of airmasses on the globe with compensating vertical motions (somehow resembling Rossby's definition from the late 1930ies of a *potential vorticity* with a certain reference latitude; "In einer gewissen mittleren Breite ist die [relative] Circulation Null"; Figure 3) In the later sketch emphasis is put on the vertical motion, combined with the claim that vortex tubes raise from the ground in region of cyclonic circulation ("Wo man am Erdboden auf der nördlichen Halbkugel zyklonische Horizontalzirkulation hat, steigen Wirbelröhren aus dem Boden empor"; Figure 4).

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 (cf. Annex below)? *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?

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 Exner (1917), Haurwitz (1941), Raethjen (1953) [only the later example of Pichler (1983) 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 exchanges (e.g. Zardi and Rotunno 2004).

Concluding remark

The main purpose of this presentation is to remind the scientific community about the existence of the Bjerknes scripts. Some 40 pages have been carefully scanned and will be distributed on compact disc to interested parties. In such a way it is hoped that the full relevance of the well preserved early example of professorial service to students can be determined by interested historians of science.

Annex: Memories about V. Bjerknes's later visits to Leipzig (by Ludwig Weickmann jun., *1919)

During the 1920ies and 1930ies Vilhelm Bjerknes 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; professor in Leipzig 1923-1945; cf. Börngen und Weickmann 2003] and our guest left soon after a talkative breakfast and returned quite late. Bjerknes 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] Bjerknes.

While these visits in our home did not really interfere with my boyhood life, I remember one evening when V. Bjerknes 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. Bjerknes joined the group. When at a late hour the question of "closing the session" came up, Bjerknes 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 "Bjerknes Theorem", but from the result at home there appear to have been some iterations).

Vilhelm Bjerknes'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 Bjerknes looked serenely at me through the smoke

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Figures:



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 Haus in Nürnberger Straße 57

Photo: Michael Börngen



Figure 2: Vilhelm Bjerknes (1862-1951) during his time in Leipzig (1913-1917). Source: Börngen and Ziehmann (2003)

Die von den polaren Gebieten stammenden Kreise werden mit stark anticyklonischer Cirkulation die Äquatorialen Gebiete erreichen. Gleichzeitig werden die aus den Äquatorialen Gebieten stammenden Kreise die polaren Gebiete erreicht haben, und hier mit stark cyclonischer Cirkulation auftreten. In einer gewissen mittleren Breite ist die Cirkulation Null: Hier befinden sich Kreise, die dieser Breit entstammen nur dass diejenigen, die früher in höherem Niveau waren, jetzt nach einer Passage imdemoxa durch das polare Gebiet in einer unteren Niveau angekommen sind, und diejenigen, die früher in unteren Niveau waren, jetzt nach einem Ausflug in Äquatorialer Richtung in dem höheren Niveau angekommen sind. Auf den Anfangszustand

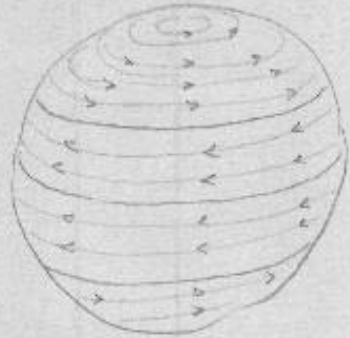


Figure 3: Example from lecture notes of 1914: page 12 of Chapter VII „Taking into account the Earth's rotation“. Doubled spaced typed script in the left column, idealized sketch of the global circulation along latitude circles (in pencil) in the right one.

82. DIE WIRBELRÖHREN IN DER ATMOSPÄRE. ↘

Man kann sich leicht einen allgemeinen Ueberblick über die Wirbelverteilung in der Atmosphäre schaffen.

Man wo man am Erdboden auf der nördlichen Halbkugel syklonische Horizontalzirkulation hat, steigen Wirbelröhren aus dem Boden empor. Wo antisyklonische Horizontalzirkulation vorliegt, steigen sie zum Boden herab. Auf der südlichen Halbkugel umgekehrt. Jetzt ist die allgemeine Windverteilung: Ostwind im Äquatorialgebiet zwischen den Rossbreiten,

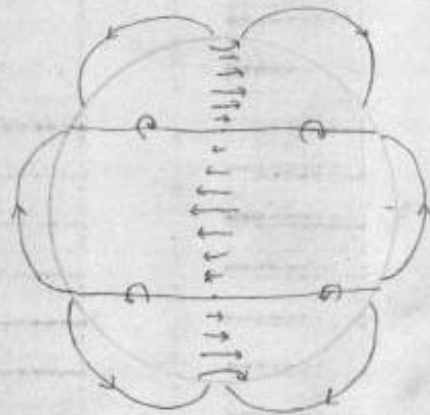


Figure 4: Example from lecture notes of 1917: Begin of Section 82 „Vortex tubes in the atmosphere“. Doubled spaced typed script in the left column, idealized sketch of the three-dimensional global circulation (in pencil) in the right one.