The Heidelberg Aelotron—a new facility for laboratory investigations of small-scale air-sea interaction

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Purpose

The study of small-scale air sea interaction still lacks suitable facilities. No facilities are available with large fetches and correspondingly high wave ages. Furthermore almost no large facility is suitable for measurements with sea water, is clean enough for controllable experiments with surface films or sufficiently gastight for gas exchange measurements.
Currently a new large annular wind/wave facility with quasi unlimited fetch is under construction at the Institute for Environmental Physics of Heidelberg University. An annular facility is not a new idea. A 40 m diameter facility ("storm basin") was already built shortly after World War II in Sevastopol for wind/wave interaction studies. Various small circular facilities for air-sea gas exchange studies have been used since the late 70ties at Heidelberg University and later at Woods Hole Oceanographic Institution for air-sea gas exchange studies.

Comparison of some of the world's largest wind/water facilities

	KA	HH	M	D	SIO	HD1	HD2	HD3
Length (resp. mean perimeter) [m]	15	24	40	100	40	1.57	11.6	29.2
Width of water channel [m]	1.8	1.0	2.6	8.0	2.4	0.10	0.3	0.63
Outer diameter [m]	-	-	-	-	-	0.60	4.0	9.93
Inner diameter [m]	-	-	-	-	-	0.40	3.4	8.67
Max. water depth [m]	0.3	0.5	0.8	0.8	1.5	0.08	0.25	1.20
Water surface area [m^2]	27	24	104	800	96	0.16	3.5	18.4
Water volume [m^3]	8	12	83	768	144	0.01	0.87	22.1

Comparison of major facilities for small-scale air-sea interaction studies:
Institute for Hydrology, University of Karlsruhe (KA),
Bundesanstalt für Wasserbau, Hamburg (HH),
IMST, Univ. Marseille, France (M),
Delft Hydraulics, Delft, The Netherlands (D),
Hydraulic Facility, Scripps Institution of Oceanography, La Jolla, USA (SIO),
Small annular wind/wave flume, Univ. Heidelberg (HD1, no longer operational),
Large annular wind/wave flume, Univ. of Heidelberg (HD2, until 1998),
Planned "Aelotron", Univ. Heidelberg (HD3, in operation 1999).

Construction details

- Annular channel, 0.63 m wide, 2.41 m high, mean circumference 29.2 m;
- Paddle wheel driven by 64 100 W DC motors to generate wind speeds up to 15 m/s, time constant about 2 s;
- Water channel 0.63 m wide and 1.2 m deep. At least at low and medium wind speeds high wave ages can be obtained. The maximum phase speed of waves is 3.45 m/s; the maximum wavelength for a deep water wave is 3 m.
- Separate water flow system with speeds up to 0.5 m/s with and against the wind
- Air conditioning system with independend control of humidity and air temperature, 40 kW cooling, 20 kW heating power, high positive and negative heat fluxes at the water interface of more than 1 kW/m^2
- Switchable and controllable air flush systems with rates up to 1000 m^3/h; maximum evaporative cooling about 0.5 kW/m^2
- Separate 28 m^3 storage tanks for sea water and deionized water (Fig. 2f)
- Separate water flow system with speeds up to 0.5 m/s against the wind direction

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Unique features

Only available large facility with the combination of the following features:

- Homogeneous wave pattern and the largest possible fetch through its annular shape
- Deep enough to get high wave ages at low and medium wind speeds (maximum phase speed of waves is 3.45 m/s; the maximum wavelength for a deep water wave is 3 m)
- Very clean conditions (deionized water)
- Suitable for measurements with sea water
- Well insulated for measurements between 5 and 35°C (maximum heat flux in/out the facility of about 100 W/K
- Gastight air space
- Especially designed for IR imaging of the water surface and imaging of waves, water flow, and air-water gas transfer
- Fast gas exchange measurements by measuring the rate of concentration increase in the gastight air space:

$$\frac{\Delta c_a}{c_w} = \frac{V_w}{V_a}\frac{\Delta t}{\tau}$$

Because $V_w \approx V_a$ and concentration changes of trace gases in the air, c_a of about 2 % of the concentration in the water, c_w, can be measured, a measurement takes only about 1/50 of τ, e. g., 2–60 min. (τ ranges from about 2 hours at 15 m/s to 60 hours at 2.5 m/s wind speed.)

Impressions from the construction

*Fig. 2: **a** New building of the Institute for Environmental Physics in construction; **b** room below the facility; **c** to **e** interior of the annular wind/wave tunnel; **f** two rows of storage tanks, one for sea water and one for deionized water*

Time schedule

- Begin of detailed planning: February 1997
- Begin of construction: April 1988
- Ready for first measurements: May 1999