RHEOLOGICAL PARAMETERS OF THE AIR-SEA INTERFACE EXTRACTED FROM THE GRAVITY-CAPILLARY REGION OF WIND WAVES SPECTRUM

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Summary: A new method for extracting rheological parameters of a film covered air-sea interface, based upon measurements of spectra of wind excited gravity-capillary waves, is described and discussed.

Resumé: Une nouvelle méthode pour l'extraction des paramètres rheologiques d'une interface air-mer couverte de film, basèe sur des mesures spectrales des ondes excitèes par le vent, est décrite et expliquèe.

According to Hasselmann[(1)], the source function in the energy balance equation of a fetch-limited wave spectrum involves the sum of three terms, S_{in} (input from the atmosphere), S_{nl} (non-linear wave-wave transfer) and S_{ds} (dissipation). Terms S_{in} and S_{ds} strongly depend upon the rheological situation of the sea surface, which affects the frictional velocity, u^*, as well as the damping coefficient of the gravity-capillary waves.

In presence of surface-active films at the air-sea interface, the fetching efficiency decreases, while the dissipation in the liquid increases, with important effects for the surface dynamics of the sea.

According to the chemical nature of the surface-active substance composing the film, the film results either an adsorption film (soluble), or a spreading film (insoluble).

We have discovered that on a rippled interface in presence of a monolayered film, the ratio[(2)],

$$y_D = \frac{\text{(ripple damping in film-covered water)}}{\text{(ripple damping in purely viscous water)}}$$

plotted vs. frequency, passes through a maximum. Frequency and amount of maximum uniquely characterize the substance forming the film.

The above-mentioned ratio may also be acquired by comparison of two spectra, namely, the spectrum of wind excited waves on a film covered sea surface, and the analogous spectrum measured on a purely viscous surface under the same wind excitation. The ratio,

$$y_I = \frac{\text{(spectral intensity in purely viscous water)}}{\text{(spectral intensity in film-covered water)}}$$

is such that for the gravity-capillary portion of the spectrum is $y_I = y_D$.

In practical cases, the spectrum in purely viscous water falls into the dynamic equilibrium range predicted by Phillips.

The spectrum measured in film covered surfaces offers, therefore, a method for obtaining y_D. Using this method, we have experimentally determined frequency and damping ratio of maxima of y_D for the following monolayered films: methyl palmitate, oleyc alcohol, cetyl alcohol, methyl oleate, TritonX100, and Ligurian Sea water.

Best fitting of experimental data with calculated y_D's results in the characterization of the film (or films) in rheological parameters[3].

In conclusion, the gravity-capillary spectrum represents an ideal method for studying natural films over the sea surface, since it offers measurements integrated over a wide area without physical or chemical perturbation of the film.

Bibliography

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