The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
https://doi.org/10.5194/tc-2022-75-RC1, 2022

Comment on tc-2022-75

Anonymous Referee #1

Referee comment on "A collection of wet beam models for wave–ice interaction" by Sasan Tavakoli and Alexander V. Babanin, The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-75-RC1, 2022

Thank you for the opportunity to give a peer review of this interesting article, “A Collection of Wet Beam Models for Wave-Ice Interaction”.

Summary:

The article contributes to the wave-ice interaction, especially modeling the wave decay and dispersion when surface water waves propagate through an ice cover. The authors assumed the sources of wave energy dissipation from two mechanisms: one is water wave forces, and the other is the mechanical behavior of the ice layer, denoted as the fluid-based and solid-based energy damping mechanisms, respectively. They present “wet-beam” models that introduce the wave radiation term (heave direction only) in the Euler-Bernoulli beam theory and different rheologies for ice. The considered rheologies contain Kelvin Vogit (KV) model and Maxwell model and use pure elastic material as reference. Relevant dispersion relations are deduced.

The decay rates and wavenumbers are calculated using the dispersion relations with tuned rheological parameters to fit measurements from fields and lab flumes. The measurements cover landfast ice, broken ice from fields, and two lab flumes experiment with viscoelastic material and freshwater ice. The wet beam models using viscoelastic materials can agree with the measured wave decay rates in the landfast ice and broken ice fields. However, for freshwater ice, the models cannot give a well fit for decay rate and dispersion at the same time. The discrepancy is solved by introducing three-parameter viscoelastic rheologies into their dispersion relations.

The study found that the fluid-based energy damping mechanism is dominant for long waves, and the solid-based mechanism is important for short waves. The damping term in the wave radiation plays a more important role in decay rate than the added mass term. The heave added mass term can affect the wavenumber. It is also interesting to find that the equivalent Young Modulus of an SLS-type material using Maxwell approach is close to what is measured in dry tests.

The proposed idea of considering wave radiation in modeling waves propagating through ice cover will be of interest to the readership of the journal. Please see my reports below:

General Comments:

- A few typos need to be corrected, which are listed in the specific comments.
- Do the dispersion relations Eqs. (13-15) have multiple roots features like the models mentioned in Mosig(2015)? For example, Figure 2 of Mosig (2015) shows a root distribution in the wavenumber and attenuation domain. In other words, are there multiple roots solved from Eqs. (13-15) satisfying $k_i>0$ in this work? If so, what are the criteria for choosing the dominant root?
- What is the reason for using different dimensionless viscosities for KV model and Maxwell model in the last row of figure 2?
- It is unclear what value of the added mass coefficient A is used except in Figure 4 of this manuscript.
- Is there a comparison of wavenumber corresponding to the wave decay rate comparison with Wadhams et al. (1988) and Meylan et al. (2014) in figure 6? It would be comprehensible to have such a comparison.
- Do you consider the wave excitation force to be another necessary potential source? Because the excitation forces, radiation forces, and static forces are the common forces that need to be considered in hydrodynamics. It could occur in low ice concentration fields of ice floes.

Specific Comments:

Line 117, Eq. (9), shear stress modulus G_E is equal to shear modulus G. Do you mean G is the elastic modulus or Young's modulus?

Line 157, ko is not claimed.

In the bottom row of Figure 2, the Elasticity number corresponding to the dashed gray curve is not specified. By the way, the right column could be removed since the data are already presented in the other columns.

In figure 3, the FS model corresponding to the blue curve is not defined in the left panel. in the right panel, what is the reason for the sudden drop of the blue curve near the nondimensional wavenumber = 580ï¼□

Line 230, it seems to be a typo, change the word ‘travailing’ to ‘traveling’

Line 243, I feel the paragraph is confusing, except “The heave added mass coefficient is seen to affect the dispersion process of waves propagating into the cover with lower

Rigidity”, which can be read from Figure 2(right). It is acceptable to continue with “ the heave added mass coefficient can …”. But I don’t see why it ‘matches with’ large rigidity.

Line 276 typo, correct the word ‘viscoelastic’.

Figure 6’s caption, a typo, move a ‘by’ from '... data measured by by Wadhams et al. (1988), upper row, and Meylan et al. (2014) …'.

The fluid damping coefficient B of red solid curves in the legends in the top row of Figure 8 is partially missed technology.

Line 322, change “Left and right panels … Maxwell and KV materials.” to “Left and right panels … KV and Maxwell materials.”

Line 455, a grammar error in “dispersion curves Maxwell model give is sensitive to dynamic viscosity”