Notes on the function gsw_ionic_strength_from_SA(SA)

This function, **gsw_ionic_strength_from_SA**(SA) evaluates the ionic strength of seawater, defined by equation (5.12) of Millero *et al*. (2008) in terms of the molality of seawater m_{SW} and the valence factor $\left\langle Z^2 \right\rangle$ of sea salt The definition of ionic strength is

$$I = \tfrac{1}{2} m_{SW} \left\langle Z^2 \right\rangle . \tag{1}$$

The valence factor $\left\langle Z^2 \right\rangle$ is the mole fraction-weighted squared charge of the ions comprising sea salt, and for Reference-Composition Seawater is found by Eqn. (5.9) of Millero *et al*. (2008) to be exactly

$$\left\langle Z^2 \right\rangle = 1.245\ 289\ 8 . \tag{2}$$

This constant value of the valence factor is returned by the GSW function **gsw_valence_factor**. The molality of seawater m_{SW} can be found from **gsw_molality_from_SA**(SA) and is given by

$$m_{SW} = \frac{S_A}{(1 - S_A) M_S} . \tag{3}$$

where M_S is the mole-weighted average atomic weight of the elements of sea salt. The paper which defines the Reference-Composition Salinity Scale, Millero *et al*. (2008), derives M_S to be the value

$$M_S = 31.403\ 821\ 8...\ \text{g mol}^{-1} = 0.031\ 403\ 821\ 8...\ \text{kg mol}^{-1}, \tag{4}$$

and this value can be found by calling **gsw_atomic_weight**. In Eqn. (3) Absolute Salinity S_A must be in units of kg kg^{-1} which means that M_S must be in units of kg mol^{-1} in this equation. Molality m_{SW} is given by the GSW function **gsw_molality_from_SA**(SA) in units of mol kg^{-1}.

Ionic strength I is given by the GSW function **gsw_ionic_strength_from_SA**(SA) in units of mol kg^{-1}.

Strictly speaking, Eqn. (3) and hence Eqn. (1) apply only to seawater of Reference Composition because the values of M_S and of $\left\langle Z^2 \right\rangle$ which are used are the values for Reference-Composition seawater. The value of the mole-weighted average atomic weight of the elements for seawater of arbitrary composition is unknown, as is the valence factor for seawater of arbitrary composition. If ionic strength is required to an accuracy of better than 0.1% it is suggested that you contact the authors for further guidance.

References

Millero, F. J., R. Feistel, D. G. Wright, and T. J. McDougall, 2008: The composition of Standard Seawater and the definition of the Reference-Composition Salinity Scale, *Deep-Sea Res. I*, **55**, 50-72.