## S1 Computing expected parameter occurrences

We can calculate approximate expected parameter occurrences $\mathbb{E}_d^{\mathrm{S}}[\boldsymbol{\phi}(\cdot);\boldsymbol{\theta}]$ based on ConsProb's sparse posterior probabilities; for example, $\mathbb{E}_d^{\mathrm{S}}[\boldsymbol{\phi}(\cdot);\boldsymbol{\theta}]$'s element corresponding to CONTRAlign's matching emission parameter $\theta_{\mathtt{AA}}^{\mathrm{match}}$ is

$$\sum_{uv} p_{uv}^{\mathrm{M}}(\boldsymbol{\theta};d) I\{[t(u),t(v)] = (\mathtt{A},\mathtt{A})\}.$$

Here, $p_{uv}^{\mathrm{M}}(\boldsymbol{\theta};d)$ is the explicit form of each sparse matching probability $p_{uv}^{\mathrm{M}}(\boldsymbol{\theta})$ regarding each $d$-th RNA sequence pair.