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$$\tan \frac{x}{2} = \frac{\sin \frac{x}{2}}{\cos \frac{x}{2}} = \frac{2 \sin \frac{x}{2}}{2 \cos \frac{x}{2}} = \frac{2 \sin \frac{x}{2} \cos \frac{x}{2}}{2 \cos^2 \frac{x}{2}} = \frac{\sin x}{1 + \left(2 \cos^2 \frac{x}{2} - 1\right)} = \frac{\sin x}{1 + \cos x}$$