

$$v_{Na} = 115\text{mV}, \quad v_K = -12\text{mV}, \quad v_{Na} = 10.6\text{mV}, \quad C = 1\mu\text{Farad/cm}^2,$$

where " Ω " is one Ohm, the unit of resistance.

Non-dimensionalise with $v = v/v_{Na}$ and $\tau = t/[5\text{ms}]$, as $\tau_n(v) \sim O(5\text{ms})$, and we have

$$\begin{aligned} \epsilon \frac{dv}{d\tau} &= I_{ext} - g(v, n) \stackrel{\text{def}}{=} I_{ext} - [m_{\infty}^3(v)(0.85 - n)(v - 1) + \gamma_K n^4(v + v_K) + \gamma_L(v - v_L)] \\ \frac{dn}{d\tau} &= k(v, n) \stackrel{\text{def}}{=} \frac{1}{\tau_n^*(v)} [n_{\infty}(v) - n], \end{aligned} \quad (21)$$

with

$$\epsilon = \frac{C}{G_{Na}[5\text{ms}]} = 2 \times 10^{-3}, \quad \gamma_K = \frac{G_K}{G_{Na}} \sim 0.3, \quad \gamma_L = \frac{G_L}{G_{Na}} \sim 3 \times 10^{-3},$$

$$I_{ext} = \frac{I_{ext}}{G_{Na}v_{Na}}, \quad v_K = -\frac{v_K}{v_{Na}} \sim 0.1, \quad v_L = -\frac{v_L}{v_{Na}} \sim 0.1, \quad \tau_n^*(v) = \tau_n(v)/[5\text{ms}] \sim O(1).$$

We can now sketch the nullclines, and noting the different timescales of the membrane potential response to the gating variable response (as $\epsilon \ll 1$) we can consider the phase plane trajectories in terms of fast and slow dynamics.

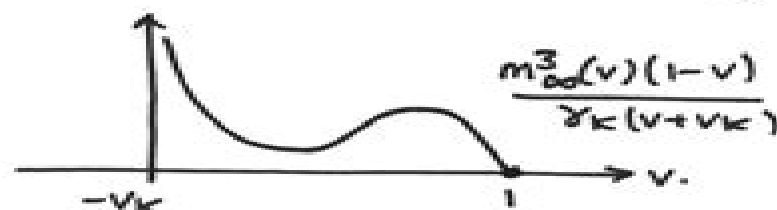
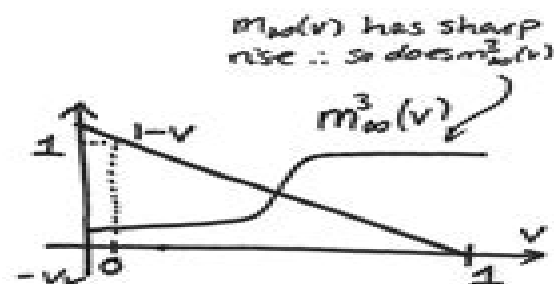
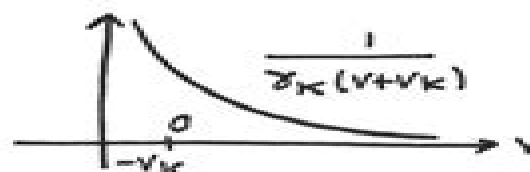
Plotting nullclines. $I_{ext} = 0$.

$$\begin{aligned} -\epsilon dv/d\tau = g &= m_{\infty}^3(v)(0.85 - n)(v - 1) + \gamma_K n^4(v + v_K) + \gamma_L(v - v_L) \\ dn/d\tau = k &= \frac{1}{\tau_n^*(v)} [n_{\infty}(v) - n] \end{aligned}$$

γ_L small: neglect this below.

v nullcline

$$\frac{n^4}{0.85 - n} = \frac{m_{\infty}^3(v)(1 - v)}{\gamma_K(v + v_K)}$$



Mathematical Physiology

Victor R. Squires



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Mathematical Physiology: Cellular physiology James P. Keener, 2009

Mathematical Cardiac Electrophysiology Piero Colli Franzone, Luca Franco Pavarino, Simone Scacchi, 2014-10-30 This book covers the main mathematical and numerical models in computational electrocardiology ranging from microscopic membrane models of cardiac ionic channels to macroscopic bidomain monodomain eikonal models and cardiac source representations These advanced multiscale and nonlinear models describe the cardiac bioelectrical activity from the cell level to the body surface and are employed in both the direct and inverse problems of electrocardiology The book also covers advanced numerical techniques needed to efficiently carry out large scale cardiac simulations including time and space discretizations decoupling and operator splitting techniques parallel finite element solvers These techniques are employed in 3D cardiac simulations illustrating the excitation mechanisms the anisotropic effects on excitation and repolarization wavefronts the morphology of electrograms in normal and pathological tissue and some reentry phenomena The overall aim of the book is to present rigorously the mathematical and numerical foundations of computational electrocardiology illustrating the current research developments in this fast growing field lying at the intersection of mathematical physiology bioengineering and computational biomedicine This book is addressed to graduate student and researchers in the field of applied mathematics scientific computing bioengineering electrophysiology and cardiology

Applied Mathematical Models in Human Physiology Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, 2004-02-01

This book introduces mathematicians to real applications from physiology Using mathematics to analyze physiological systems the authors discuss models reflecting current research in cardiovascular and pulmonary physiology In particular they present models describing blood flow in the heart and the cardiovascular system as well as the transport of oxygen and carbon dioxide through the respiratory system and a model for baroreceptor regulation This is the only book available that analyzes up to date models of the physiological system at several levels of detail both simple real time models that can be directly used in larger systems and more detailed reference models that show the underlying physiological mechanisms and provide parameters for and validation of simpler models The book also covers two dimensional modeling of the fluid dynamics in the heart and its ability to pump and includes a discussion of modeling wave propagation throughout the systemic arteries

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Modeling Human Atrial Patho-Electrophysiology from Ion Channels to ECG - Substrates, Pharmacology, Vulnerability, and P-Waves Loewe, Axel, 2016-08-03 Half of the patients suffering from atrial fibrillation AF cannot be treated adequately today This book presents multi scale computational methods to advance our understanding of patho

mechanisms to improve the diagnosis of patients harboring an arrhythmogenic substrate and to tailor therapy The modeling pipeline ranges from ion channels on the subcellular level up to the ECG on the body surface The tailored therapeutic approaches carry the potential to reduce the burden of AF *Democratic Global Governance* Irene Lyons

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