

| In [13]: | <pre>V = np.linspace(-150,150,100)  # Computing the different times of activation of each gate tau_m = tm(V) tau_n = tn(V) tau_h = th(V)  fig, ax = plt.subplots(figsize=(15, 5),nrows=1, ncols=2, constrained_layout=True) ax[0].plot(V,tau_m,label='m gate') ax[0].plot(V,tau_n,label='m gate')</pre>  |
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|          | ax(0].jut_label(Y,taub_label), intiver=12); ax(0].jut_label(Y,taub_label), intiver=12); ax(0].jut_label(Y,taub_label), intiver=13); ax(0].jut_label(Y,taub_label), intiver=14); ax(0).jut_label(Y,taub_label), intiver=14); ax(0).jut_label(Y,taub_lab   |
|          | Idea        |
|          | C+ktKqU4qpiiiuLqXW1h8Qb5Yuid7feDEodxKAUbxqcOphhacOI9cceUl4kVCqra9m1r5y8kgr2FFewp6SSPSUVFJRWUrS/isKySgr3 VIFUVsW+8mqKy6uoqD70M9+cKJ8RE+UJNspHTGCK9vuI8XuPUX4j2uct7+b3EeUzb/Ibfp837zPD7w0/z/AH5r1l3m5GN2+Gz2f4ArX A/D6v9pgF5rlyXlnw1n1lg8sBzoFlB15XNw/UlzTznlO/rbr5+nLB5YPrm9NYTbSGSxrbTktq1x26rla/5FD04a+twmor8dVW4Qt6tI PmvckOel7tPbrqQHlv3ueqsVpv8rm6ctWYq/ze76qx2prA6+qWe/PmavC5Gqy2CnM1B8q5msC8V+bAa2oDr6vF5w6+fimouQhQAkTkq O3Zv4e3N77NxUMv5qpRV9Uv/zLvS6546wrmb5rPhUMuDF2AIiJtbOrUqbz88sucfvrp5OTk80WXXwKwb98+EhISSELJYdeuXbz99tuc dtppACQlJVVFcXEyPHj2YPHkyN910E+vWreo44446jrKyMrVu3MnTo0BAeVbvaCvQPmu8HbG+soHPuKeApgOzs7Da/95kQncCzA89s681 2CrWultKqUooqitizfw95+/PYXbab3WW72V6ynQ1FG1i4fSFVtVUAxPhiGNtrLBN7T2TiMRMZ03MMMf6YEB+FdGbVNbXsKCpn455SNu WXkptfxta9ZewoKmd7YT17SioafV1SbBSpCdGkxseQ2i2avqnxJMVFkxwXRWJsFElxUXSL9Z53i/HTLcZ7jI/xExftJy7KR3yMn9goP 36fmpZ1iNpaqCqDqv0HPlaXB+bLvWXV+73n1fuhuiKwrMIrVz9VBD0GntdUHlhWUwnVlVATeN4uDPzR4IsGf1TgscG8Lwp8foiqex4L Pl/QuiivrPkDrw2UN/+B9T5/k8vSeolop2NrmhIg0in9ZfVfqK6tZmbwzIOWj+oxioHJA3ljwxtKgIhIp3LjjTdy5ZVXMmbMcMaPH8+ YMMNISUlhyJAhjB8/npEjRzJo0KD6Ji4A119/PTNmzKBPnz588MEHPPvsslx++eVUVHgX7Pfff39nToD8HbjzzF7Cu/1UFIr+P6R5Pv ORFJPkNWVN6tdomeraaraVbGNd4TqW7VrG4p2LeWL5E8xmNonRiZyTeQ7fGPoNRqR3/IW2dC75JRWs2L6PVTv2SXpNMSt3FrN+dwmVN QdqbMRF++jfvRt9UuPJ6p1Mn9Q4+qTE0TMplh6J3pSeGENslD+ER9IF1NZARfGBqb1k6HlpYAp+XhL0vMybr0tyVJyeSHQcCV8URMUF ptgGz2MhJgG6pXnP/bEGyRN4jAV/zIHHRp9HB+ajvdfUP697rEtoxBxIUNQ/75qfQwtJvclQy87OdnU92YscTkVNBWf99SzG9BjD/03 7v0PWP/H5Ezyx/AnmXTyP3gm9QxChiIS71StXkpWVFeowWqWmpoaqqiri4uJYv34906ZNY82ancTEto3d78b0jZktdc5lt+m0jpKzvQ icBvQAdgH3AtEAzrknzasD/Ru8kWLKgKudc4e92NA1SWQoqihiya41zN80n/c2vUdFTQVZaVlcPPRizhUHt2iu4U6RAlzzjnW7Cphy aYClm7ay7JNe8nNPzBseO/kOIb3SWJY7yQG9UggIz2BjB4J9EqKVWe/baGmGsoLYX8h7N974H153VQUmPZ5jxX7vORGeeCxqrRl+zE/ xCRCbCJEd/OSETEJgefdILpuPv7Ay3S3wGPgeVRcYFkcRMUf+uhXnY001tx1id4N6XTe2vAWBeUFzBoxq9H152Wex+zls3lzw5t8Z/R   |
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|          | CdDj98D3pFn/ieTmpp8VJie8YyPHq401E6nF7BvRgaOZTs0uxjX5R0rntv75I/u49IFhGR9ooHCg95XLT/uYOMMfHA5cBTfswl10jrWk lixjclgYBp6e/93yCl1tVTVN5KmBqgi002oAOILlsKih2Hhr9wV++vfhJcuv1eysbmRZduWMWnAJIwxTsfpkFJjU8kpzTl+46IL/giB wfDR/e5/QyIi0h4t/UA68pvrX4H7rbVNxx3ImNuMMSuNMSul11r8Zkc2rqoSGg0UVxd7ffis4koAUuNVABGR7kMFEG9raoQFd7u3Mq T/CK56ocv3dMgpzaFqXxWnJ2j7y7GkxKZQsbeCopqiY18UPgAmPw55C2HdAv+FExHpmoqAqYc8Tgc2HXFN0jDXGFMAXAU8aYw56qgNa +0sa226tTY9Li7OV31FDrf2bRIb3LW5/Mp8rw+/ZmsFIUEBnKwGqCLSjagA4k17a2DuDFgzG856AC7+fxDQ9ZtK/bv43wSYACb2n+h0 lA4rNTYV4Nh9QA6YcDv0S4MP74Pacj8kExHpslYAycaYRGNMD+Ba4N1DL7DWJlprXdZaF/AWcJeldr7/o4ocwVrIeRtX/KkAFFQVeH2 KZKIKUUMjCA7UnwMi0n3oo5631OyCFy+GTYvhkr/A5Aehm2wHOXD8bUSIl1Aey9DlOYQGhh6/DwhAYBBc+gTUlCMnD/knn1h1F2StbQ Tuxn26y3rgDWvtWmPMHcYY3xypIeIt21ZDxRbCU6YTExrD5krv9gdraGomp7iSMQPVAFVEuhcdg+sNpbkw+0rYUwLXvgYnX+B0Ir8pr StlXdk67h5zt9NROrTggGBGxIw48QoQgP5pcPrPYcmfIOVKSD7P9wFFRLoga+2HwIdHPNdiw1Nr7U3+yCTSKmvfhoBgGHEJSaVfkFeR 59XhN2yvZm9jM2MGqQaiIt2LVoC019Zv4LnzYN8eu0n9blX8AFi2bRmA+n+OQkpsCuvLltPQ3HDii8+8D+KGw3s/g/oq34cTERGRjsF aWDsfhp4DPaNIjkxmU8Ummm2z16ZYU7gbgNEJKoCISPeiAkh7ZL8FL/0AekbDjxdB/C1OJ/K7pUVLiQ6NZkT0CKejdHipsanUN9W371 2coBD3Vpjqbb4Ed+HExERKY6haAVUFkLKFQAkRSZR11jHtpoje/i23ZrCSmL79CAhqqfXxhQR6QxUAGkLa+GLP8G8H7mLHj9aBNFDn E71d03NTSzbvozT408nwOif0omkxKYAkFWSlbobEtIh4y5Y+Tzk/9yUUVERKTDyHkbAkPg5IsASIpKAiB3d67XplhTuJSxAyMx3aRf nyjIAfqrlVONe+Gd0+Cz38HoGXDjfOgd43QqR2SXZ105t5LT47X9pTUS+iRwUq+T+Gb7N62/afJ/QVQivHu3+5QhERER6bqam2HdfH f/r9BwATZGDAVqU8Umr0xRWddAXskeNUAVkW5JBRBP7CmDly+PrLlwzq/gsn+6typDU0uLlxJgAjhtwGlOR+kUjDFk9M/gmx3ftH4fb 49e7n9nFVvhkwd9G1BERESctfUrqN40oy4/+FSfhn0Y0HsAurXeWQGSVVQBwGgVQESkG1IBpLV2roVnzobivXDlc+4mld182eAXRV+Q Gpuq4288kDEgg8q91Wwo39D6mwZPdJ8K8+3LSP4934UTERERZ+XMg6CeMozwpvpJUUleWwGSWeguyKSpAaqIdEMqgLTG+vfh2f0gqQF u+QhSr316keMKqwrZUL6B8wbriFZPZPTPAPBSGwzAWQ9A/ZHW7j1QvcnWFNOLr7V97dmNQD7jiGWiog/13ufcIi4iISNeR/ wXUlkHK1Ue9lBSZRGNz1lurtrZrCmstaworGDMwql3jiIh0ViqAHMveGnjzJnez077R44YPIDy/06k6jMVbFjMyZiTxfeKdjtLpZPTP   |
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|          | IIIXTQmQBLOueh2/+/B3nDH6DM4Ze47b4YjLJuVO4vFzH+eiKRfx2NrHmP/MfF7e/PLAniB1b1Jz4OivwqXPw/dWwKk/gJYGeOFGZ+L UH8+B9/6sZIIIIByacBBe+gHkTYAZX3UtjO6Gv8ScPvp0LJYXNr7Qz5GJiMQ3JUASSFOwiRvfvJEsfxY3H3uzhr4I4Nwh5sZjbuRPZ/ wJj/Fw7evXcuFzF7J4++LES4QADBntDJH51mK46j04+X+gsRKevw5+NRn+fBq8/WuoLHU7UhERGWiWPwhVn8IZt4A3yzUQ9jX8JaYkp 4SpeVNZuH5hP0cnIhLf1ABJENZafrj4h2yo3cAvjv/FwJ/OUnrdccXH8dT5T/GzuT+jJlDDN1/5Jpe9eBlvbnutCCTsdnh9Y+gkJwHy 7ffgW+/CqTeDDcMrP4bfHg2/mQkv3gQb33S+1RMREelOoA5e/yWMnguTznYtjH+v3ffw15jzS85nze41rKte10+RiYjEPyVABsSDqx/ kxU0v8p2jvsNxw49zOxyJU16P13nj5/HM557h+7O/z6a6TVz161Wc+fcz+c0Hv2Fb/Ta3Q+w7BzPhxOvh8tfhmtVw9m2QMxLeuwcePA 9uGwdPfNWZULV2u9vRiohIvFm0ABor4DM/dfWOY4++t5ni7JRuh7/EnD32bHzGxzPrn+mnyERE4p9ug5sAlpQt4dfLf80Zo8/g690+7 nY4MgD4vX7+c/J/8oUJX+D1ba/z1KdPce/Ke71nxT3MHDaTk0eezPHDj2dc9rjEHEqVPQJmf9NZWhpgw+vOpHalr8DHTzvHDJ0MJadB ySkwag4kZ7gasoiIuKh2O7zzWzh8Pgw/2rUwSsvrWVRaxfVnTup2+EtMbkouJ4w4gWc3PMv3ZnwPn0fNfhERvRMOcDsadnD9G9czNms sP53708T8sCp9JsmbxBmjz+CM0Wews3EnT5c+zYubXusO9+/gjvfvoDi9mO0HH8/Wwp1My5/GiIwRifc71pwBU851FmuhfA2sfxVKX4 W198KS34HHB8NnwtgTnWXETEhKdTtyERHpL//+mfM34tQfuBrGq4s34/d6uHDWy84df37J+by29TWW1C3h+OHH93F0IiLxTwmQASwQC nDla1cTioS465S7SE9KdzskGcAkOwu5YvoVXDH9Csoaynh7x9u8te0tntnwDB+sewKAnOQcpuVP47C&wxiXPY6x2WMZnTWatKQ016Pv JcbAsKnOctx3INgMW5Y4c4RsfAPeugPevA28fucbwNFzYfRxMPIYSM5003oREekLZSvgo8dg7nedibZdUhc18vf12zh3ehF5Gck90uf EESeSnZzNwvULlQAREUEJkAErFAlx/RvXs3b3WhacsoAx2WPcDkkSSFFGEfMnzmf+xPkE10FKq0tZWbmSVZWrWFm5ksU7Fh0xkfbj04 sYnjGcwvRCitKLKEwvZFjaMHJTcs1NzSU3JZdU3wDsMZGU6gyBKTnF2W+ugS3vwOZFsGmRczeZt+4A44Fh02DUSTBytrNkj3B1jLiIi PSCSBievRrScuH4a10N5al122hqDfPVOWN6f17f6+esMWfxdonT1LfWk+1Xs15EBjc1QAagi13wo8U/4VVtr3Pz7Js5ZdQpbockCSz k8SUvC1MyZvCFyd9EYCWcAtb6fawxXaj99RtpKyhjGW711HeVE7Y7n1XmVRfK1n+LDL9mW3rDH8Gab40Un2ppCU56xxvCim+FPxePy1 ez+33+knyzLUtPo+vfTH02mM8e10Xr8eL13jxGM8eyyFLzXFm/o/N/t9sD1vfnS3vwtY18MEjzqSqAJ1FTi+REbOcITNFR2oeERGRgW bJ72H7MrjqPudvqEsiEctD72zmyJE5T895YHHMK5nH3z75Gy9vfpnPT/h8H0U501jwKAEywFhruX3p7Sxcv5crjryKL03+ktshySCU7   |
|          | E1mwpAJTBgyYY/HwpEwFc0VlDeVUx2oZndgd9tS11pHfWs99a31lDeVs75mPc2hZppCTTSHmvs8boPBYzwYY/DgrA2mbV6T2HbsP+f/6GPR8thxsb12KcD4CZhIGMJBTCQIZSvgkw/gk3ucMzw+8CY5iycJvD7AdIqvl37QA2d756klvmUlZ/GPef9wOwyRgaFqvTP3x6RzYNoFroayaH0lGyob+fWXph/wudPypzEmawz/LP2nEiAiMugpATLA3LvyXv665q98ZcpX+OYR33Q7HJE9eDleCtMLKUwvPKDzIjZCIBQgEA7QEmqhJewsgXCAUCREMBKkNdxKMBwkZEOEIiHCNkwoOr4dsRHCkXDbdsclbMNYLNZaLNbppWLpVBbbbeva53VGsvONjnY4JBrCNFdBYCU1V0FQJwYDzmDGgQkg1peZca63SxTh0Cvp6N7d6brvEdiF5LwEjcGpBD0UTcEInAwu+CNxn+41euD218cFpm8tl9nHN40QGfa4xh3vh5LFi+gK31WxmZ2bMJVEVEEpESIAPI39b+jbs/uJtzx53LDbNusLy7ccig5jEe0pLSEmdCle5YC3XbYfty2LnCmVxvx0fQsLT9mKwRUDjNwVdk2FQooAzySpyeIyIi0veWpwCb34bz7oasA0869Katu5t4de0urjp5PMk+70Fdd9xx53L38rvbehCLiAxWSoAMEA+seoA7193JSSNO4pa5t/T0fAYi0v+McSZIZR4BU89vL6/fBbtWws5VsGuVs/70ZYjNp+L1Q/5EGDoZCiY766FTYMiY6FAaERHpFbXb4KUfwtiTYMYlbkfDX5dsxmMMX5496qCvUZheyEkjTuKRNY9w8dSLyfJn9WKEIiIDh1rNcc5ay90f3M29K+/lzDFn8ovjf0GSR98CiySczGHOMv709rJgAKo+hV0fQ/lqZ731XVj1f+3HeP2QNx7yJ0D+JCdJkj/B6TGiW/OKiBwYa+HZa5zk83kLXB/6UtPUymPvbeEzU4dRnHNoQ9iuOuoq5j8zn4dWP8S3j/p2L0UoIjfwKAESx8RRMLe+eytPrHuCL0z8AjfPvhmv5+C6PorIAJSUAoWHOOtHLfVQuQ4qPoHyNVD5KexcCWuegQ63JyajSD2klsSXY+DIWOda4uISGeL74ZPX4Kzb4PcsW5Hw2/XUpDS4jrb7npOmHanLuzD4z+jm8/PHDfHnKl81Nye2FCEVEBhYlQOJUMBzkprdv4l+b/sV10y7j6hlXa84PEXEkzzq32Bl+dofyUltz14KqT6Gq1Nmu/BQ+XgjNuzscaCBruDN8JneMkxDJHevs54xxJmPV+42IDDYb34RXfgxT58Exl7sdDVuqmnjwnU3MP3okkwt728jKVUddxStbXuevK//Cdb0u65VriogMJEqAxKHK5kqufflaPij/gKtnXM3XD/+62yGJyEDgS3YmTR02dc/Hmqth9wao2gC718PujVC9Eda9BI3lnY/1Z8KQ0ZAzGnJGdVlGQkqcEiQiklhqt8OT1spDcuf9fi1aPij/gKtnXM3XD/+62yGJyEDgS3YmTR02dc/Hmqth9wao2gC718PujVC9Eda9BI3lnY/1Z8KQ0ZAzGnJGdVlGQkqcEiQiklhqt8OT1spDcuf9fi1aPij/gKtnXM3XD/+62yGJyEDgS3YmTR02dc/Hmqth9wao2gC718PujVC9Eda9BI3lnY/1Z8KQ0ZAzGnJGdVlGQkqcEiQiklhqt8OT1spDcuf9fi17e4/73xbXX4PB6u/czEXrvmu0xxnDvuXB7/5HEuOewSCtIKeu3aIiIDgRIgcWZFxQquee0a6oP13H7i7zw19iy3QxKRRJA62O+9RgBaGqB6E9RshurNznb1JidhsuF1CDZ2Pt6fAdkj2ydzzR7u3Lkmtp1zrCE2IjJwhFrhya9CKABf+mtczJ+0bHM1z60o43unTWBYVu++n145/Uqe3/g8   |
|          | Seyth Nurthity of Shrifting 13 Seyth Seyth (1994 - 1994) A Company of the Control   |
|          | I AND THE PER CONTRICTION OF THE   |
|          | ax [1].set_ylabel (r'\$n_(w)\$', fontsize=16); ax [1].set_title ('Steady-state activation of n-gates in K channels', fontsize=14);  Volump = -85.636 mV  Steady-state activation of n-gates in K channels  object  |
|          | Regarding n_inf: The m gate has a very similar distribution than the one from the n gates (they remain active in higher voltages, i.e depolarization). Nevertheless, the m-gate has a delayed but faster transition from 0 to 1. The h gate, on the other hand, is activated on low voltages and deactivated at highest ones (deactivated by depolarisation).  b) Simulate the sodium current  def dm(m,t,v):     return alpha_m(v)*(1-m)-beta_m(v)*m  def dh(h,t,v):     return alpha_h(v)*(1-h)-beta_h(v)*h  Ena = 50 # mV gna = 120e-9 # S  m0 = 0.0529   |
|          | <pre>h0 = 0.5961 dt = 0.001  t=np.arange(0,40,dt) # ms n=np.zeros(len(t)) V_set = -20*np.ones(len(t)) #constant V (mV)  # Calculating m and h values using Euler's method  m_eu_b = euler(dm,m0,40,dt,V_set) h_eu_b = euler(dh,h0,40,dt,V_set)  I_na_b = Ina(V_set,Ena,m_eu_b,h_eu_b,gna)  ind_2b_1=np.array(np.where(t==15)) ind_2b_2=np.argmin(I_na_b)</pre>   |
|          | <pre>steady_na = I_na_b[ind_2b_2] print('It can be seen that:\n- At t=15 ms, we have reached the sodium current steady state, Ina = '+</pre>   |
| In [17]: | <pre>t=np.arange(0,40,dt_c) # ms dim =12  Vc = np.linspace(-90,-42,dim) # 90 and 42 mV instead of 100 and40 because we run into a discontinuity I_na_2c = np.zeros((len(t),len(Vc)))  fig = plt.figure(figsize=(15,9))  for i in range(0,len(Vc)):      V_2c = V_clamp(Vc[i],t)      m_eu_2c = euler(dm,m0,40,dt_c,V_2c)     h_eu_2c = euler(dh,h0,40,dt_c,V_2c)      I_na_2c[:,i] = Ina(V_2c,Ena,m_eu_2c,h_eu_2c,gna)     print('The steady-state current for ' + str(round(V_2c[-1],2)) + 'mV is ' +str(round(I_na_2c[-1,i]* 10**9,2))+' pA.')      fig.add_subplot(3, 4, i+1)      plt.plot(t,I_na_2c[:,i]*10**9)# The current units before were mA, and now we set it to pA     plt.xlabel('t (ms)',fontsize=10);     plt.ylabel('I(Na) (pA)',fontsize=10);     plt.title('V clamp = ' + str(round(Vc[i],2)) + ' mV',fontsize=10);  fig.tight_layout()</pre>   |
|          | The steady-state current for -90.0mV is -0.0 pA.  The steady-state current for -85.64mV is -0.0 pA.  The steady-state current for -81.27mV is -0.0 pA.  The steady-state current for -76.91mV is -0.02 pA.  The steady-state current for -72.55mV is -0.11 pA.  The steady-state current for -68.18mV is -0.47 pA.  The steady-state current for -63.82mV is -1.7 pA.  The steady-state current for -59.45mV is -5.17 pA.  The steady-state current for -55.09mV is -12.89 pA.  The steady-state current for -50.73mV is -26.34 pA.  The steady-state current for -46.36mV is -44.35 pA.  The steady-state current for -42.0mV is -62.12 pA.   |
|          | What mechanisms are responsible for the sodium current rise and decay?  The sodium current rise (which is a negative current) is induced by the opening of the m gates (active in high voltages as we saw in 2a) and its decay is provoked by the h gates. Actually, for low values of V_clamp, the current is null because of the action of the n gates. That is why we see a fast negative peak(M gates are faster than h gates) in V_clamp<-65 plots followed by a stabilization of the current at 0 pA.  |
|          | we see a fast negative peak(M gates are faster than h gates) in V_clamp<-65 plots followed by a stabilization of the current at 0 pA.  That changes when V>-65, where higher currents start appearing and the negative spike produced by the m gates cannnot be easily compensated by the h gates and thus, we have a negative steady-state current.  d) Plot the instantaneous and steady-state I-V curves for sodium channels.   |
|          |  |

| Compare with 1d) and discuss the results.  For instantaneous I-V curves:  Loan be seen that the current is always negative for Na channels, and the I-V curve has a very small slope compared to the one hannels, which follow a steep slope distribution ranging from negative to positive values.  For standy-state I-V curves:  Loan be seen that the current is always negative for Na channels, and the I-V curve has a very small slope compared to the one hannels, which follow a steep slope distribution ranging from negative to positive values.  For standy-state I-V curves:  Loan to seen that the current is always negative for Na channels are null for both channels in case of low voltages. However, when approx. "70 mV are met, exponential curves are not not not be channels steeper and positive (outflow of IX), and the one from Na channels negative (inflow of IX).  By What happens If you repeat the voltages. However, when approx. "70 mV are met, exponential curves are not from the K channels steeper and positive (inflow of IX).  By What happens If you repeat the voltages. However, when approx. "70 mV are met, exponential curves are not from Na channels negative (inflow of IX).  By What happens If you repeat the voltages. However, when approx. "70 mV are met, exponential curves are not exposured to the standard of the standard outgates (inflow) of IX).  By What happens If you repeat the voltages. However, when approx. "70 makes speculate to expose the standard outgates (inflow) of IX).  By Line of IX A T and IX and  | ax[i].set  Sodium Potasium  10  5  (Yd) (X)  -5  | Instantane   | euos I-V curves   | (Ya) (X)  | 0 -   | Stead                                      | dy-state I-V curv                         | es                                    |
|---|--|--|---|---|---|--|---|---------------------------------------|
| what happens if you repeat the voltages flow voltages. However, when approx. 70 mV are met, exponential curves are not the K channels steeper and positive (outflow of K), and the one from Na channels negative (inflow of Na).  by What happens if you repeat the voltage clamp experiments from before (initial conditions in the conditions) of the conditions in the steeper but this time investigating the (negative) sum of both currents (f)? Plot the time cours of the conditions are considered by   | Compare with 10  For instantaneous It can be seen that channels, which for steady-state I  | d) and discuss the sire of the current is a follow a steep slope.  | he results. Iways negative for Nope distribution rangin   | la channels, and<br>ng from negative  | the I-V curve ha                                      | as a very sma<br>es.                       | Voltage (mV)                              | red to the one                        |
| print('The steady-state current for ' + str(round(V_2c(-1),2)) + 'mV is ' +str(round(1_sum-0,2)) + 'pA, ')  fig.add_subplot(3, 4, i+1)  plt.plot(t,T_sum(:,1)*10*9) # The current units before were mA, and now we set it to pA  plt.xlabe('t' (total) (pA)', fontsize=10);  plt.ylabe('t' (total) (pA)', fontsize=10);  plt.title('V clamp = ' + str(round(v(1),2)) + 'mV', fontsize=10);  fig.zipht_imyout()  the steady-state current for -90.0eV is 0.01 pA,  the steady-state current for -60.0eV is 0.02 pA,  the steady-state current for -60.0eV is 0.00 pA,  the steady-state current for -60.0eV is 0.00 pA,  the steady-state current for -60.0eV is 0.0eV is 0.00 pA,  the steady-state current for -60.0eV is 0.0eV is 0.00 pA,  the steady-state current for -60.0eV is 0.0eV is 0.0  | Both currents are one from the K che one from the K che one from the K che one of the control of the che of th | null for both char<br>nannels steeper a<br>pens if you re<br>his time inve<br>mand voltag<br>ural activity.<br>.c+I_na_2c)<br>gure (figsize= | epeat the voltaestigating the (15,9))   | of K), and the or   | e from Na chan  | nels negative                              | (inflow of Na)                            |                                       |
| The steady-state current for $-76.91\text{mV}$ is $0.02\text{ pA}$ . The steady-state current for $-76.91\text{mV}$ is $0.22\text{ pA}$ . The steady-state current for $-68.18\text{mV}$ is $-1.23\text{ pA}$ . The steady-state current for $-68.18\text{mV}$ is $-1.23\text{ pA}$ . The steady-state current for $-59.48\text{mV}$ is $-11.81\text{ pA}$ . The steady-state current for $-59.48\text{mV}$ is $-11.81\text{ pA}$ . The steady-state current for $-59.48\text{mV}$ is $-12.92\text{ pA}$ . The steady-state current for $-46.36\text{mV}$ is $-26.92\text{ pA}$ . The steady-state current for $-46.36\text{mV}$ is $-99.77\text{ pA}$ . The steady-state current for $-42.0\text{mV}$ is $-171.01\text{ pA}$ .  The steady-state current for $-42.0\text{mV}$ is $-171.01\text{ pA}$ .  The steady-state current for $-42.0\text{mV}$ is $-171.01\text{ pA}$ .  The steady-state current for $-42.0\text{mV}$ is $-36.92$ . The steady-state current for $-42.0\text{mV}$ is $-36.92$ . The steady-state current for $-42.0\text{mV}$ is $-36.92$ . The steady-state current for $-42.0\text{mV}$ is $-36.00\text{mV}$ is $-36.00\text{mV}$ .  The steady-state current for $-42.0\text{mV}$ is $-36.00\text{mV}$ is $-36.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ is $-30.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ in $-30.00\text{mV}$ is $-30.00\text{mV}$ in $-30.00\text{mV}$ | print('The steady-stead | subplot(3, 4,  (t, I_sum[:,i] el('t (ms)',fe el('I(total) e('V clamp =  yout()  tate current : tate current :                                | <pre>i+1)  *10**9) # The cu ontsize=10); (pA)',fontsize= ' + str(round(V)  for -90.0mV is for -85.64mV is for -81.27mV is</pre> | 0.01 pA.<br>0.02 pA.<br>0.03 pA.  | before were   | mA, and no                                 |   |                                       |
| Please speculate how this relates to neural activity.  It can be seen that for low clamping voltages (below -65 mV), the current after the first positive, instantaneous spike, goes to zer downeyer, that changes from -65 mV on (as seen in the steady-state IV curves), in which we can see a positive spike (due to the   | The steady-st th | ate current :  | for -76.91mV is for -72.55mV is for -68.18mV is for -63.82mV is for -59.45mV is for -55.09mV is for -46.36mV is for -42.0mV is  | s 0.02 pA.<br>s -0.21 pA.<br>s -1.23 pA.<br>s -4.34 pA.<br>s -11.81 pA.<br>s -26.92 pA.<br>s -54.2 pA.<br>s -99.77 pA.<br>-171.01 pA. | 3 2 - (pd) 1 - (pd) 0 - 1 - 1 2 2                     | p = -81.27 mV                              | - ((total) (pA)                           | V clamp = -76.91                      |
| Please speculate how this relates to neural activity.  It can be seen that for low clamping voltages (below -65 mV), the current after the first positive, instantaneous spike, goes to zer dowever, that changes from -65 mV on (as seen in the steady-state IV curves), in which we can see a positive spike (due to the  | V clam  V clam  V clam  V clam  V clam  V clam  10  V clam   | t (ms)<br>pp = -72.55 mV<br>20 30 40<br>t (ms)   | 0 10 1<br>t(<br>V clamp =   | ms) = -68.18 mV  (40) (Fig. 1) 20 30 40 ms) = -50.73 mV   | -3.2 -3.4 -3.6 -3.8 -4.0 -4.2  V clam  V clam  V clam | t (ms)<br>p = -63.82 mV<br>20 30<br>t (ms) | -3 - 0 0 -2 - 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | t (ms) V clamp = -59.45  10 20 t (ms) |
|   | Please speculate t can be seen that  | e how this relate<br>at for low clampin<br>anges from -65 m  | es to neural activity g voltages (below -6  | 20 30 40 ms)  7. 65 mV), the curre e steady-state IV  | nt after the first curves), in whic                   | t (ms)  positive, insta  h we can see      | ntaneous spik                             | t (ms)<br>e, goes to zer              |
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