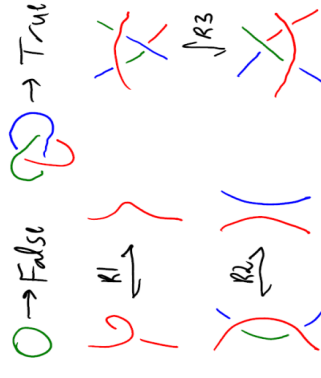


**Problem** Prove that  $O \neq \emptyset$ .

**Proof** Define an "invariant"

$I(D) := \begin{cases} 0 & \text{if } D \text{ can be coloured RGB} \\ \text{else} & \text{so that all crossings are} \\ & \text{wavy and every crossing} \\ & \text{is either mono- or tri-chromatic} \end{cases}$   
 $E \in \{ \text{True, False} \}$



Taken from

Rob Scharein's site, <http://knotplot.com/zoo/>

$\Rightarrow$  Knot Colouring isn't enough.

## Algebraic Knot Theory

Colloquium in Mathematics

University of Copenhagen, October 9, 2008

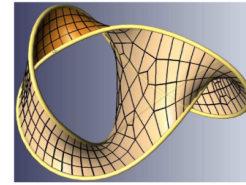
**Abstract.** The right objects of study in algebraic knot theory are not spaces, but rather, "spaces and maps between them". In a similar spirit I will start this right theory to study knot theory and Jones polynomials, but rather, "knots and maps between them". In the world of knot theory (and the basic operations between them) many interesting properties of knots become "definable". This I find myself again studying the good old Kontsevich integral - the best example I know of in algebraic knot theory - but my perspective this time is completely different.

| Menu                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Transparencies |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| <ul style="list-style-type: none"> <li>Some very basic knot theory.                             <ul style="list-style-type: none"> <li>The three-colouring invariant.</li> <li>The Kauffman bracket and the Jones polynomial.</li> </ul> </li> <li>Three things we'd like to understand:                             <ul style="list-style-type: none"> <li>The genus of a knot.</li> <li>The crossing number of a knot.</li> <li>Open questions and progress.</li> </ul> </li> <li>Algebraic knot theory and TG-morphisms.                             <ul style="list-style-type: none"> <li>Aside 1: KTG is finitely generated (and presented).</li> <li>Aside 2: Knot is related to Drinfeld</li> </ul> </li> <li>A word about "definable" sets.                             <ul style="list-style-type: none"> <li>A very strong TG-morphism exists! (But it is too hard.)</li> <li>Definable sets of the Alexander polynomial.</li> <li>Definable sets of the Jones polynomial.</li> <li>Internal quotients. (Likely more than just Lie algebras, may have "moduli" rather than just discrete points).</li> </ul> </li> <li>Open questions and progress.</li> </ul> |                |

Also see my talk in Aarhus, June 2007. Much progress was made since, but the introductory talk (this one) remains more or less the same.

### Three Basic Problems

October 08-09  
12:40 PM



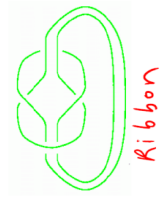
Drawn using SelfView, <http://www.math.toronto.edu/~drorbn/selfview/>

1. Determine the "genus" of a knot.
2. Determine the "unknotting number" of a knot.
3. Decide if a knot is "Ribbon".

"Ribbon singularity", allowed



(Image by J. Jost)



"cusp", not allowed



(Image by J. Jost)



|                |                |                |                |                |                |                |                |                |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 | 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|                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |      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| 0 <sub>1</sub> | 0 <sub>2</sub> | 0 <sub>3</sub> | 0 <sub>4</sub> | 0 <sub>5</sub> | 0 <sub>6</sub> | 0 <sub>7</sub> | 0 <sub>8</sub> | 0 <sub>9</sub> | 0 <sub>10</sub> | 0 <sub>11</sub> | 0 <sub>12</sub> | 0 <sub>13</sub> | 0 <sub>14</sub> | 0 <sub>15</sub> | 0 <sub>16</sub> | 0 <sub>17</sub> | 0 <sub>18</sub> | 0 <sub>19</sub> | 0 <sub>20</sub> | 0 <sub>21</sub> | 0 <sub>22</sub> | 0 <sub>23</sub> | 0 <sub>24</sub> | 0 <sub>25</sub> | 0 <sub>26</sub> | 0 <sub>27</sub> | 0 <sub>28</sub> | 0 <sub>29</sub> | 0 <sub>30</sub> | 0 <sub>31</sub> | 0 <sub>32</sub> | 0 <sub>33</sub> | 0 <sub>34</sub> | 0 <sub>35</sub> | 0 <sub>36</sub> | 0 <sub>37</sub> | 0 <sub>38</sub> | 0 <sub>39</sub> | 0 <sub>40</sub> | 0 <sub>41</sub> | 0 <sub>42</sub> | 0 <sub>43</sub> | 0 <sub>44</sub> | 0 <sub>45</sub> | 0 <sub>46</sub> | 0 <sub>47</sub> | 0 <sub>48</sub> | 0 <sub>49</sub> | 0 <sub>50</sub> | 0 <sub>51</sub> | 0 <sub>52</sub> | 0 <sub>53</sub> | 0 <sub>54</sub> | 0 <sub>55</sub> | 0 <sub>56</sub> | 0 <sub>57</sub> | 0 <sub>58</sub> | 0 <sub>59</sub> | 0 <sub>60</sub> | 0 <sub>61</sub> | 0 <sub>62</sub> | 0 <sub>63</sub> | 0 <sub>64</sub> | 0 <sub>65</sub> | 0 <sub>66</sub> | 0 <sub>67</sub> | 0 <sub>68</sub> | 0 <sub>69</sub> | 0 <sub>70</sub> | 0 <sub>71</sub> | 0 <sub>72</sub> | 0 <sub>73</sub> | 0 <sub>74</sub> | 0 <sub>75</sub> | 0 <sub>76</sub> | 0 <sub>77</sub> | 0 <sub>78</sub> | 0 <sub>79</sub> | 0 <sub>80</sub> | 0 <sub>81</sub> | 0 <sub>82</sub> | 0 <sub>83</sub> | 0 <sub>84</sub> | 0 <sub>85</sub> | 0 <sub>86</sub> | 0 <sub>87</sub> | 0 <sub>88</sub> | 0 <sub>89</sub> | 0 <sub>90</sub> | 0 <sub>91</sub> | 0 <sub>92</sub> | 0 <sub>93</sub> | 0 <sub>94</sub> | 0 <sub>95</sub> | 0 <sub>96</sub> | 0 <sub>97</sub> | 0 <sub>98</sub> | 0 <sub>99</sub> | 0 <sub>100</sub> | 0 <sub>101</sub> | 0 <sub>102</sub> | 0 <sub>103</sub> | 0 <sub>104</sub> | 0 <sub>105</sub> | 0 <sub>106</sub> | 0 <sub>107</sub> | 0 <sub>108</sub> | 0 <sub>109</sub> | 0 <sub>110</sub> | 0 <sub>111</sub> | 0 <sub>112</sub> | 0 <sub>113</sub> | 0 <sub>114</sub> | 0 <sub>115</sub> | 0 <sub>116</sub> | 0 <sub>117</sub> | 0 <sub>118</sub> | 0 <sub>119</sub> | 0 <sub>120</sub> | 0 <sub>121</sub> | 0 <sub>122</sub> | 0 <sub>123</sub> | 0 <sub>124</sub> | 0 <sub>125</sub> | 0 <sub>126</sub> | 0 <sub>127</sub> | 0 <sub>128</sub> | 0 <sub>129</sub> | 0 <sub>130</sub> | 0 <sub>131</sub> | 0 <sub>132</sub> | 0 <sub>133</sub> | 0 <sub>134</sub> | 0 <sub>135</sub> | 0 <sub>136</sub> | 0 <sub>137</sub> | 0 <sub>138</sub> | 0 <sub>139</sub> | 0 <sub>140</sub> | 0 <sub>141</sub> | 0 <sub>142</sub> | 0 <sub>143</sub> | 0 <sub>144</sub> | 0 <sub>145</sub> | 0 <sub>146</sub> | 0 <sub>147</sub> | 0 <sub>148</sub> | 0 <sub>149</sub> | 0 <sub>150</sub> | 0 <sub>151</sub> | 0 <sub>152</sub> | 0 <sub>153</sub> | 0 <sub>154</sub> | 0 <sub>155</sub> | 0 <sub>156</sub> | 0 <sub>157</sub> | 0 <sub>158</sub> | 0 <sub>159</sub> | 0 <sub>160</sub> | 0 <sub>161</sub> | 0 <sub>162</sub> | 0 <sub>163</sub> | 0 <sub>164</sub> | 0 <sub>165</sub> | 0 <sub>166</sub> | 0 <sub>167</sub> | 0 <sub>168</sub> | 0 <sub>169</sub> | 0 <sub>170</sub> | 0 <sub>171</sub> | 0 <sub>172</sub> | 0 <sub>173</sub> | 0 <sub>174</sub> | 0 <sub>175</sub> | 0 <sub>176</sub> | 0 <sub>177</sub> | 0 <sub>178</sub> | 0 <sub>179</sub> | 0 <sub>180</sub> | 0 <sub>181</sub> | 0 <sub>182</sub> | 0 <sub>183</sub> | 0 <sub>184</sub> | 0 <sub>185</sub> | 0 <sub>186</sub> | 0 <sub>187</sub> | 0 <sub>188</sub> | 0 <sub>189</sub> | 0 <sub>190</sub> | 0 <sub>191</sub> | 0 <sub>192</sub> | 0 <sub>193</sub> | 0 <sub>194</sub> | 0 <sub>195</sub> | 0 <sub>196</sub> | 0 <sub>197</sub> | 0 <sub>198</sub> | 0 <sub>199</sub> | 0 <sub>200</sub> | 0 <sub>201</sub> | 0 <sub>202</sub> | 0 <sub>203</sub> | 0 <sub>204</sub> | 0 <sub>205</sub> | 0 <sub>206</sub> | 0 <sub>207</sub> | 0 <sub>208</sub> | 0 <sub>209</sub> | 0 <sub>210</sub> | 0 <sub>211</sub> | 0 <sub>212</sub> | 0 <sub>213</sub> | 0 <sub>214</sub> | 0 <sub>215</sub> | 0 <sub>216</sub> | 0 <sub>217</sub> | 0 <sub>218</sub> | 0 <sub>219</sub> | 0 <sub>220</sub> | 0 <sub>221</sub> | 0 <sub>222</sub> | 0 <sub>223</sub> | 0 <sub>224</sub> | 0 <sub>225</sub> | 0 <sub>226</sub> | 0 <sub>227</sub> | 0 <sub>228</sub> | 0 <sub>229</sub> | 0 <sub>230</sub> | 0 <sub>231</sub> | 0 <sub>232</sub> | 0 <sub>233</sub> | 0 <sub>234</sub> | 0 <sub>235</sub> | 0 <sub>236</sub> | 0 <sub>237</sub> | 0 <sub>238</sub> | 0 <sub>239</sub> | 0 <sub>240</sub> | 0 <sub>241</sub> | 0 <sub>242</sub> | 0 <sub>243</sub> | 0 <sub>244</sub> | 0 <sub>245</sub> | 0 <sub>246</sub> | 0 <sub>247</sub> | 0 <sub>248</sub> | 0 <sub>249</sub> | 0 <sub>250</sub> | 0 <sub>251</sub> | 0 <sub>252</sub> | 0 <sub>253</sub> | 0 <sub>254</sub> | 0 <sub>255</sub> | 0 <sub>256</sub> | 0 <sub>257</sub> | 0 <sub>258</sub> | 0 <sub>259</sub> | 0 <sub>260</sub> | 0 <sub>261</sub> | 0 <sub>262</sub> | 0 <sub>263</sub> | 0 <sub>264</sub> | 0 <sub>265</sub> | 0 <sub>266</sub> | 0 <sub>267</sub> | 0 <sub>268</sub> | 0 <sub>269</sub> | 0 <sub>270</sub> | 0 <sub>271</sub> | 0 <sub>272</sub> | 0 <sub>273</sub> | 0 <sub>274</sub> | 0 <sub>275</sub> | 0 <sub>276</sub> | 0 <sub>277</sub> | 0 <sub>278</sub> | 0 <sub>279</sub> | 0 <sub>280</sub> | 0 <sub>281</sub> | 0 <sub>282</sub> | 0 <sub>283</sub> | 0 <sub>284</sub> | 0 <sub>285</sub> | 0 <sub>286</sub> | 0 <sub>287</sub> | 0 <sub>288</sub> | 0 <sub>289</sub> | 0 <sub>290</sub> | 0 <sub>291</sub> | 0 <sub>292</sub> | 0 <sub>293</sub> | 0 <sub>294</sub> | 0 <sub>295</sub> | 0 <sub>296</sub> | 0 <sub>297</sub> | 0 <sub>298</sub> | 0 <sub>299</sub> | 0 <sub>300</sub> | 0 <sub>301</sub> | 0 <sub>302</sub> | 0 <sub>303</sub> | 0 <sub>304</sub> | 0 <sub>305</sub> | 0 <sub>306</sub> | 0 <sub>307</sub> | 0 <sub>308</sub> | 0 <sub>309</sub> | 0 <sub>310</sub> | 0 <sub>311</sub> | 0 <sub>312</sub> | 0 <sub>313</sub> | 0 <sub>314</sub> | 0 <sub>315</sub> | 0 <sub>316</sub> | 0 <sub>317</sub> | 0 <sub>318</sub> | 0 <sub>319</sub> | 0 <sub>320</sub> | 0 <sub>321</sub> | 0 <sub>322</sub> | 0 <sub>323</sub> | 0 <sub>324</sub> | 0 <sub>325</sub> | 0 <sub>326</sub> | 0 <sub>327</sub> | 0 <sub>328</sub> | 0 <sub>329</sub> | 0 <sub>330</sub> | 0 <sub>331</sub> | 0 <sub>332</sub> | 0 <sub>333</sub> | 0 <sub>334</sub> | 0 <sub>335</sub> | 0 <sub>336</sub> | 0 <sub>337</sub> | 0 <sub>338</sub> | 0 <sub>339</sub> | 0 <sub>340</sub> | 0 <sub>341</sub> | 0 <sub>342</sub> | 0 <sub>343</sub> | 0 <sub>344</sub> | 0 <sub>345</sub> | 0 <sub>346</sub> | 0 <sub>347</sub> | 0 <sub>348</sub> | 0 <sub>349</sub> | 0 <sub>350</sub> | 0 <sub>351</sub> | 0 <sub>352</sub> | 0 <sub>353</sub> | 0 <sub>354</sub> | 0 <sub>355</sub> | 0 <sub>356</sub> | 0 <sub>357</sub> | 0 <sub>358</sub> | 0 <sub>359</sub> | 0 <sub>360</sub> | 0 <sub>361</sub> | 0 <sub>362</sub> | 0 <sub>363</sub> | 0 <sub>364</sub> | 0 <sub>365</sub> | 0 <sub>366</sub> | 0 <sub>367</sub> | 0 <sub>368</sub> | 0 <sub>369</sub> | 0 <sub>370</sub> | 0 <sub>371</sub> | 0 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