Solutions to General Relativity by Wald

Daniel J. Cross.

November 17, 2008

Chapter 2 Solutions

a) Show that the overlap functions f_i[±] ◦ (f_j[±])⁻¹ are C[∞], thus completing the demonstration given in section 2.1 that S² is a manifold.

- b) Show by explicit construction that two coordinate systems (as opposed to the six used in the text) suffice to cover S². (It is impossible to cover S² with a single chart, as follows from the fact that S² is compact, but very open subset of R² is noncompact.)
- a) The maps are defined as acting on the standard embedding of the sphere into ℝ³. f_i[±] is a projection of upper (lower) hemisphere into the plane, for example

$$f_2^{\pm}(x^1, x^2, x^3) = (x^1, x^3),$$

and the others are similar. The inverse map stretches the plane up or down into the corresponding hemisphere,

$$(f_2^{\pm})^{-1}(y^1, y^2) = (y^1, \pm \sqrt{1 - ((y^1)^2 + (y^2)^2)}, y^2),$$

and so on. The overlap map then projects out two of these coordinates, so up to exchanging coordinates it is either of the two maps

$$(y^1, y^2) \longrightarrow (y^1, y^2)$$

 $(y^1, y^2) \longrightarrow (y^i, \pm \sqrt{1 - ((y^1)^2 + (y^2)^2)}).$

both of which are C^{∞} in their domain of definition, $(y^1)^2 + (y^2)^2 < 1$.

b) Construct a chart by drawing a line from the north pole N through any given point p ≠ N on the sphere. The point where this line hits the plane x³ = 0 is the image of p under the chart. This map is defined for all points except N and is called stereographic projection from N. A similar chart defined at S (or any other chart about S) then together with the first form an atlas for S². An explicit form of the map can be found geometrically. The line through p and N (thought of as vector in R³) is (with N = (0, 0, 1))

$$p + t(p - N) = (t(1 + p^1), t(1 + p^2), t(1 + p^3) - t).$$

Solving for when $x^3 = 0$ we get

$$t = \frac{p^3}{1 - p^3}$$
.

which then gives

$$x^i = \frac{p^i}{1-p^3}.$$

The inverse maps are found similarly by starting with a point (y^1, y^2) in the plane, constructing the line N + t(N - y) through N and y and finding where this hits the sphere:

$$1 = |x(t)|^2 = (y^1)^2 t^2 + (y^2)^2 t^2 + (t+1)^2,$$

which has solution

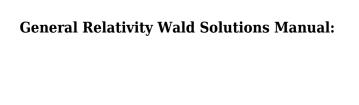
$$t = \frac{-2}{1 + |y|^2}$$

and gives the mapping

$$(y^1,y^2) \mapsto \frac{1}{1+|y|^2}(2y^1,2y^2,|y|^2-1).$$

General Relativity Wald Solutions Manual

JL Elias



This book delves into General Relativity Wald Solutions Manual. General Relativity Wald Solutions Manual is a vital topic that must be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and indepth insights into General Relativity Wald Solutions Manual, encompassing both the fundamentals and more intricate discussions.

- 1. This book is structured into several chapters, namely:
 - Chapter 1: Introduction to General Relativity Wald Solutions Manual
 - Chapter 2: Essential Elements of General Relativity Wald Solutions Manual
 - Chapter 3: General Relativity Wald Solutions Manual in Everyday Life
 - Chapter 4: General Relativity Wald Solutions Manual in Specific Contexts
 - ∘ Chapter 5: Conclusion
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 - The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of General Relativity Wald Solutions Manual.

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