Test Doc

**Redshifts and Distances**

|  |  |
| --- | --- |
|  | (1) |

|  |  |  |
| --- | --- | --- |
| Random table |  |  |
|  |  |  |

Tensor to block indices and the four alternate characters

|  |  |
| --- | --- |
|  | (1) |

The covariant derivative  is defined for contra- and co-variant vectors as

|  |  |
| --- | --- |
|  | (2) |

and

|  |  |
| --- | --- |
|  | (3) |
|  | (4) |

where  is the Christoffel symbol or connection.

|  |  |
| --- | --- |
|  | (4) |

**Summary**

In section 8.5 we are looking at redshifts and distances. The latter are more complicated than you might think! We start in an FLRW universe with metric

|  |  |
| --- | --- |
|  | (5) |

We then found a rank 2 Killing tensor

|  |  |
| --- | --- |
|  | (6) |

where  is the 4-velocity of (all) comoving observers and . We proved it is a Killing tensor in 'Commentary 8.5 Killing Tensor in FLRW spacetime'.

**The Business**

Extending our rule about Killing vectors a bit (Carroll 3.175) we have  is conserved along geodesics.  is the four-momentum of some (any) particle. Mass is conserved so that means if its four velocity is

|  |  |
| --- | --- |
|  | (7) |

is conserved for the particle along geodesics. Call the conserved quantity  and

|  |  |
| --- | --- |
|  | (8) |

is constant for the particle along geodesics.

**Massive particles (interstellar gas)**

For massive particles  and so

|  |  |
| --- | --- |
|  | (9) |

where we introduced  where  is very like the three-velocity of the particle. Since we are thinking of a particle on a geodesic, it is in free-fall. We also have  so (8) becomes

|  |  |
| --- | --- |
|  | (10) |
|  | (11) |